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R. H. STINCHFIELD, *Editor*

Editorial Office: 1155 16th Street, N. W., Washington 6, D. C.

VOLUME XXXIII NO. 4

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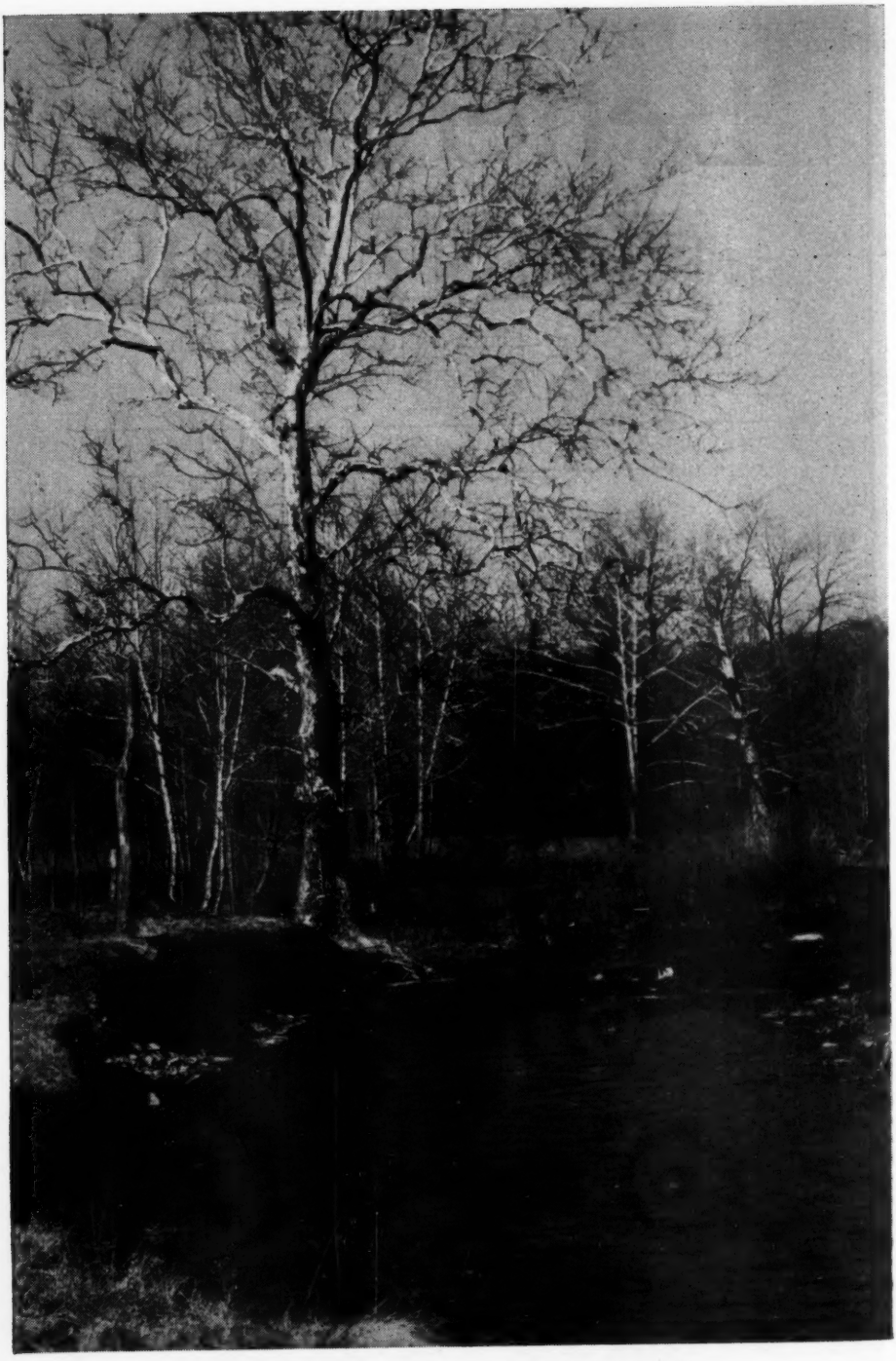

The Old Swimming Hole Opens Up

Better Crops with PLANT FOOD

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VOL. XXXIII WASHINGTON, D. C., APRIL 1949 No. 4

But not with . . . .

Covered Wagons

Jeff McDermid

ROLLING heavily over prairie sod and mountain meadows, the mammoth "O" of the covered wagon wheel in overland migrations stood for Opportunity—just as the big "S" in Savings today means Security. You and I can travel faster; see, hear, and talk farther, and live better than our ancestors; but we're just as anxious to hold up our heads and be useful, thrifty, and independent as they were. Sure 'nough, the old Wild West is mostly gone, but we've got new and strange Frontiers that call for a grubstake, pardner!

To tell adequately about the countless caravans in covered wagons that went West in 1849 to seek gold, fertile farms, or other emblems of Opportunity, I'd only be repeating all the standard chronicles of Francis Parkman, Prof. Archer Hulbert, and H. H. Bancroft. My present "yen" is to link the lonely wagon-borne family of 1849 in its search for Security with the complex, bustling, modernized American's organized way of getting it.

Two uncles of mine were among the Argonauts of the Gold Rush who helped swell California's population from a reputed 6,000 to a hustling 260,000 in four short years. One was a drover, the other a mule skinner; and neither one got any more bonanza out of the diggings than Jim Marshall himself, who found the first gold flakes at Sutter's Fort in 1848—and died dirt poor and crazy as a loon. They reckoned in the heyday of their youth that they would rather be duped by a Pacific Eldorado than to stay near the Atlantic, to be made suckers of by stony farms, gouging mortgage rates, the Know-Nothing party, and P. T. Barnum.

In time the older uncle got his fill of prairie cholera, camp-fire chilblains, burnt biscuits, buffalo trail bunions, "Injun" hysteria, alkali asthma, raging floods, hell-diving mudholes, and murderous mules. So he came limping back to dig his "pay dirt" with a plow in Illinois. But the younger one was more romantic and pliable. He found himself a native California wife and got his fill of Opportunity and Security by raising 14 children and a creditable set of pioneer whiskers.

Now to be right honest about it, I never saw my Uncles Hiram and Charley, or "fabulous Frisco" for that matter. But that doesn't hurt my imagination any or stop me from looking back through the hindsights to see what a lot of ambitious farm folks had to put up with, all the way from St. Louis, Independence, and Ft. Leavenworth, clear up through Platte Valley, Ft. Hall, the Salt Lake trail, and Carson Sink to reach Sacramento and "Security." Yet I came myself with another wayfaring outfit into the rattlesnake and tumbleweed country sixty years afterward, only we didn't spell Opportunity with the big bull wheels of the prairie schooner any longer.

IT WAS the Pennsylvania Dutchmen of Lancaster County's rich garden spot who built and greased the wheels of Opportunity with the original granddaddy of the prairie schooner in 1750 or thereabouts. Those 3,500-pound, ponderous, six-horse tumbrels of hewn timber and bowed canvas tops were dubbed "Conestogas." The name came from the Conestoga Valley and a tribe of Indians who were offshoots of the Susquehannas. Of course, other big wagons of similar style were made for the overland journey at Pittsburgh, Cincinnati, and St. Louis.

Loaded to the "gunwales" with rations—salt pork, bacon, ham, flour, and coffee—plus shooting irons and ammunition to help live off the country and resist enemies, those huge wagons marked the last link with old homes and the main hope for the future.

Trappers, speculators, traders, gamblers, adventurers, miners, and restless, disgruntled farmers moved across the trails first blazed in a covered wagon by Marcus Whitman, to reach a land of unsettled and uncertain economy. Get this main thought as contrast with our frontiers today—the farmers had only three reliances for investment. They wagered their *land, their livestock, and their lives.* They threw in those stakes because they stood alone with no dependable form of organized society or government stability to lean upon. Their best form of mutual security was the defensive ring of wagons circling a community campfire. Even that was not always proof from quarreling, dishonesty, and desertion.

THE U. S. Government was not looking for creditors to any extent in those times. The Mexican war was a push-over, and there were not many heavy public obligations to finance. (Nobody imagined what 15 years more would bring.) To the tune of "O, Susannah," and with the dubious exploits of John C. Fremont in mind, the public was ripe for a plunge. Added to the already clamorous Oregon settlement urge, my uncles and their ilk could see no more beds of ease in the East, heavily blanketed with mortgages. Turning to the setting sun was their idea of a new dawn of enterprise and investment. So when first news of the gold strike on the Sacramento came to eastern communities via the Sandwich (Hawaiian) Islands and Cape Horn, the risky goal of "easy money" found thousands ready to wager land, livestock, and lives to find it.

Thus, on top of a fleeting and unreliable form of collateral our numerous kinsfolk took on another hazard—digging for treasure in an unknown land where they faced extravagance, speculation, and the wildest form of inflated values. I don't know which one to ad-

mire the most—the uncle who got his fingers burned and came home admitting defeat, or the younger one who finally found Security beyond the Sierras. They both went through some of the tribulations of that feverish boom era, unprotected by stabilized investment. Let's look at a few.

Take incredulity first. Folks were ready to believe anything about sudden wealth possibilities and fixed up utterly impossible equipment with which to

win those buried fortunes. A book called Three Weeks in the Gold Mines, written by a mendacious adventurer who had never been west of the Hudson, told how the author picked up $50,000 in gold dust in 10 days with no other implement than a penknife! Hundreds of raw inventions for washing out the nuggets from "pay dirt" were shipped to San Francisco by men who never engaged in mining, and these crazy trappings rotted on the beach. Ergo, you can't get either Opportunity or Security through misinformation. Not even today, when the public is largely safeguarded from fake investments.

Second, it was a game for hardy youngsters. The physical life was extremely hard, and only the most fit survived. The best mining was done by young men, and they usually stuck the longest and got the most—if they escaped loan sharks and gamblers. In modern times the rewards of a settled agriculture belong to the old and the middle-aged as well, provided the safest form of investments are relied upon.

It was an era of exploitation. Each man sought treasure and welfare for himself and his family, and devil take the rest! Natural riches of mine and soil were alike seized and borne to more congenial climes. There was no thought of anybody else's private comforts or of the public good. I presume my two uncles were just as indifferent and greedy as the rest. Naturally, you don't build prosperity or lasting Opportunity and safe investments on any such a shaky foundation. Certainly we pursue a better course today, with countless State and Federal projects afoot and sound industrial progress usually connected with safe rather than speculative ends.

Inflation and speculation ruled in 1849-50. In one year 50,000 persons swarmed into San Francisco's crude outpost built to accommodate 1,000. Aside from the regular wide-open gambling, which was the gaudiest luxury of the age, the new settlers in "them thar hills" played a "pyramid club" game of kiting values. Storekeepers in rough shacks paid $3,000 per month rent; picks and shovels often cost $20 each; good boots were $100 a pair; the smallest circulating coin was a quarter; and bread was fifty cents a loaf—such as it was and when you could get it. If we imagine ourselves in a pickle over current prices, all I can say is we were born a century too late! But, unfortunately, such unseemly pioneer risks and price levels were the best kind of investment that the country afforded—until the bubble broke. Lets thank our stars we can find better places to refrigerate our nest eggs today.

PUBLIC improvements, public safety, and police protection—forms of activity deemed essential to stability and sound investment today—were unknown to the Argonauts of the Gold Rush, and only added as necessity or convenience required. Our

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Nothing Like Nodules for Nitrogen in Forage Production[1]

By A. R. Midgley and K. E. Varney

Agronomy Department, University of Vermont, Burlington, Vermont

NITROGEN is needed for proper growth of all plants and for the production of valuable protein for animal feeds. However, protein is the most expensive part of feed for livestock—in fact, farmers find that nitrogen is the most expensive constituent in both feeds and fertilizers. The dairyman's problem is to obtain nitrogen in his cattle feed at the lowest possible cost. Since nitrogen costs more than the same weight of phosphorus and potash combined in fertilizers, considerable emphasis should be placed on using minerals to indirectly supply the needed nitrogen and protein in forage production. Legumes have this power because they are able to get large amounts of nitrogen from the air.

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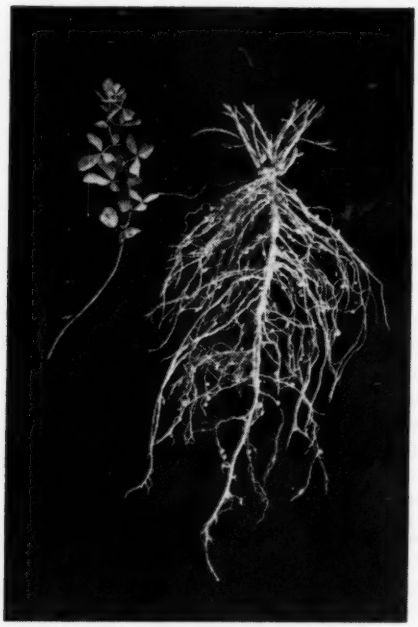

Fig. 1. This is a typical broadleaf birdsfoot trefoil plant, *Lotus corniculatus*. Note the extensive tap root and rounded leaflets. Compare this with the narrowleaf type in Fig. 2.

Nitrogen-gathering Value of Birdsfoot Trefoil

Birdsfoot trefoil is a long-lived, triple-purpose legume because it is good for pasture, hay, and grass silage. The technical name for the broad-leafed variety is *Lotus corniculatus*. While it is not even closely related to yellow trefoil or black medic, *Medicago lupulina*, the two are sometimes confused. For simplicity, birdsfoot trefoil will merely be called "Lotus" in this paper.

In the early spring of 1948, Lotus was seeded on a heavy clay soil that was so devoid of nitrogen that grasses and most weeds made practically no growth even when minerals and lime were applied. Lotus under similar conditions made a very good growth because it was able to supply its own nitrogen. During the fall of the first year the tops, roots, and nodules were obtained separately from several representative areas. The yield and nitrogen content of each were calculated to an acre basis and are presented in Table I.

As previously stated, this land was so low in nitrogen that grass and weeds

Fig. 2. Narrowleaf birdsfoot trefoil, *Lotus corniculatus*, var. *tenuifolius*. This strain usually has a more extensive fibrous root system and more pointed leaves than the broadleaf type. This may explain why the narrowleaf type does better than broadleaf on wet soils. One-year-old plant. Compare with Fig. 1.

made practically no growth even with lime and minerals, yet this legume produced more than a ton of dry matter and nearly 58 pounds of nitrogen the first year. This amount of nitrogen purchased in the fertilizer bag would cost over $12 at present prices. It is admitted, however, that this land seems to be ideal for this legume and that it made a better growth than is usually expected for Lotus.

TABLE I.—YIELD AND NITROGEN CONTENT PER ACRE OF TOPS, ROOTS, AND NODULES OF ONE-YEAR-OLD LOTUS PLANTS.

Part of plant	Per cent nitrogen	Lbs. of dry matter	Lbs. of nitrogen
Top (stems & leaves)	2.56	1,100	28.2
Lateral roots	2.17	282	6.1
Taproots	2.24	476	10.7
Nodules	6.50	193	12.5
Total	.....	2,051	57.5

The data also show that the nodules contain a higher percentage of nitrogen than any other part of the plant. The actual amount of nitrogen in them depends greatly on their age and size. Large nodules usually contain more because they have less surface-supporting tissue. While the amount of nitrogen in the nodules may appear high, it is actually about two per cent lower than that reported for the Lotus plant by other workers.

In another study the root and top growth of some two-year-old Birdsfoot trefoil plants grown on good soil conditions were studied. These were found to produce about 6,000 pounds of air-dried top growth and 2,800 pounds of roots per acre. These plots were well limed and mineralized, but in spite of the fact that no nitrogen was used, they contained 120 pounds of nitrogen in

the tops and 53 pounds in the roots and nodules. At present fertilizer prices, the cost to purchase this nitrogen would be about $35.

Grasses Versus Legume (Lotus) on a Heavy Clay Soil

It is relatively easy to grow such legumes as alfalfa, red clover, and ladino clover on good soils with adequate moisture, drainage, and fertility; but on the poorly drained, heavy Panton clay soils in the Champlain Valley these legumes grow poorly and seldom live over two years. Without nitrogen either from the fertilizer bag or from legumes, grasses grow poorly. In fact, much of this soil area is so void of good vegetation that it is frequently called "poverty flats." Field experiments were conducted on this area to see if a legume (Lotus) could be successfully grown and thus supply needed nitrogen for the soil. On an adjoining area, an experiment using grasses with high-nitrogen fertilizers also was carried on, because it was feared no legume would grow. Part of the information sought, therefore, was to determine whether grasses or legumes would produce the most efficient and economical forage on this soil when each was properly fertilized and managed.

One half acre of this land was limed, seeded to reed canary grass, and then treated with various rates of high-nitrogen fertilizer. Another half acre was similarly limed, seeded to a mixture of Lotus and reed canary grass, and given different mineral fertilizers. No potash was used in the grass fertilizer, because previous experiments had shown that this particular clay soil contained adequate amounts for grass. The yield, protein content, and fertilizer cost for each treatment on the grass and legume-grass fields are given in Table II.

A study of these results shows that good forage yields can be obtained from this soil if properly fertilized. Even though purchased nitrogen was expensive, it still produced considerable feed when used on grass. However, much greater yields and better quality of feed were produced at lower cost when the legume was used. In fact, the fertilizer cost per ton of legume hay was only about one third as much as that needed to produce grass. Furthermore, the

(*Turn to page* 44)

TABLE II.—COMPARATIVE YIELD, PROTEIN CONTENT, AND FERTILIZER COST IN GROWING GRASS VERSUS LEGUMES ON PANTON CLAY. TWO-YEAR AVERAGE, 1947-48.

Fertilizer lbs. per acre N–P_2O_5–K_2O	Pounds per acre		Cost of fertilizer used [1]	Fertilizer cost per ton of hay [2]
	Hay	Protein		
	(Reed Canary Grass)			
15–15–0	3,184	252	$ 4.50	$ 2.83
30–30–0	3,802	304	9.00	4.73
45–45–0	5,114	428	13.50	5.28
30–15–0	2,944	249	7.50	5.10
60–30–0	4,916	391	15.00	6.10
	(Lotus & Reed Canary)			
0–45–0	5,176	659	4.50	1.74
0–45–15	5,865	747	5.25	1.79
0–60–15	7,546	960	6.75	1.79
15–45–15	5,677	723	8.25	2.90

[1] Fertilizer cost based on following: nitrogen, 20¢; P_2O_5, 10¢; and K_2O, 5¢ per pound.
[2] The amount of hay produced without fertilizer was not considered here. No treatment produced 1,291 and 3,775 lbs. respectively.

Keys to Abundance

O. W. Willcox

Ridgewood, New Jersey

AMONG the inexorable facts of nature that confront humanity is the law of diminishing returns in agriculture. This "law," developed from the experience of agriculturists everywhere, states that although an increase in the fertility of a poor soil will be followed by an increased yield of plant substance, the *increase* becomes less and less as more and more fertilizer is added, until the plants finally cease to respond to more plant food. The evident conclusion is that it is impossible to produce an unlimited amount of vegetable substance on a limited area of land in one cycle of plant life.

On the other hand, humanity is confronted by the fact that the area of arable land on this earth is limited. The limits on the area of arable land and on the productivity of that area combine to put an upper limit on the number of people who may comfortably exist in a given region. As population increases, the land becomes saturated and oversaturated with people, with all the social and political consequences to which Malthus was the first to call attention.

The first essential thing to do with a problem that involves a limit is to define and quantitatively assess the limit. In the food-and-population problem, the limit might be described as the maximum capacity of land to produce food. However, the modern agrobiologist prefers to state the problem thus: The ultimate limit on food production depends on the capacities of plants to make use of the materials which the soil and its surroundings afford them. It is the plants themselves that set the final limit on food production. The agrobiologist phrases it this way: An unlimited quantity of vegetable substance cannot be produced on a limited area of land because every kind of plant, by its nature, possesses only a limited "quantity of life." The problem is thus a matter of determining the quantity of life that is or may be possessed by plants.

Quantity of life as a genetic character of a plant species is measured by the quantity of dry vegetable substance the species can produce when it is grown on a unit area of perfertile soil at the agrobiologic maximum density of stand. A definition of perfertile soil will appear farther on.

The problem of measuring the quantities of life possessed by plants was started on the way to its solution 40 years ago when Mitscherlich (1) discovered what he called the "effect law of the factors of plant growth" and found that he could express it by the equation

$$dy/dx = (A - y) \cdot c$$

Mitscherlich's law and its equation have become the base of a new quantitative science of plant life. They have been the means of uncovering quantitative and stoichiometric evidence of the identity of the protoplasmic bases of all rooted and green-leaved plants, thus providing the evolutionists with additional evidence that such plants have been derived from one original stock. They have enabled the agrobiologists to bring to the practical art of crop nutrition a definiteness that heretofore has been lacking in this subject. In con-

junction with the newly recognized inverse yield-nitrogen law they have brought to notice quantitative relations between plants and their growth factors by which man, if he will, may provide himself with a superabundance of vegetable products for a very long time to come. In view of present knowledge of the real dimensions of the power of plants for growth and yield it may be said that, in principle, the race against increasing world hunger has already been won.

Before Mitscherlich, no one had essayed to define the quantitative relation between rate of increase of the factors of plant growth and the diminishing rate of increase of yield, and there was no conception, in a quantitative sense, of what final result that process might eventually reach. The effect law replaces this indefiniteness with concreteness. In words, the Mitscherlich yield equation says that the increase of any crop under the action of increasing amounts of any growth factor x is proportional to the difference between a yield y obtained at any stage and a certain maximum yield A; c represents a constant number which depends on the nature of the growth factor and is independent of the nature of the crop.

The Constant c

The constant c has a unique significance which is best explained in connection with Fig. 1. In this Figure the three continuous curves represent the yields of three common crop plants: soybean, corn, sugar beet. The vertical axis represents quantity of dry vegetable substance produced on a unit area of normal soil. The horizontal axis shows units a, b, c, d . . . p of any particular factor of plant growth. In this example the independent variable x is supposed to be assimilable nitrogen in the soil. All other factors are supposed to be present in adequate amount, and all hostile influences are supposed to be absent.

Fig. 1 is to be contemplated in view of two commonly known facts. One is that soybean, corn, and sugar beet are very different kinds of plants; botanists assign them to different plant families. The other fact is that when soybean, corn, and sugar beet are grown under the same normal conditions they give very different yields of total dry substance, soybean consistently yielding the least and sugar beet the most. The agrobiologist expresses this by saying that these species have different quantities of life.

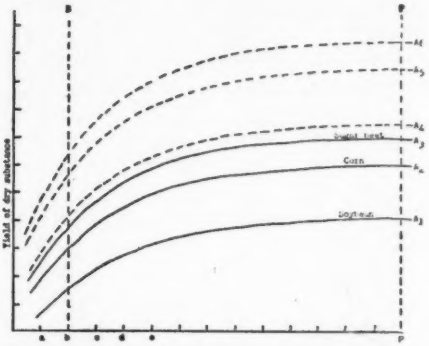

Fig. 1. Nitrogen in the soil. Diagrammatic illustration of the uniform nutrition pressures of the same growth factor on different kinds of plants.

With these particulars in mind, observe the three continuous curves in Fig. 1. They rise as more and more nitrogen is added to the soil and gradually flatten out as they approach the maximum yields, A_1, A_2, A_3, that are possible under the prevailing circumstances. These curves are typical representations of the law of diminishing returns. Observe also that the curve for soybean reaches the lowest and the curve for sugar beet the greatest height. Next, observe the broken perpendicular line B at the point on the horizontal axis representing b units of soil nitrogen, and note that this line intersects all three curves.

The situation along the line B introduces us to one of the crucial points of the agrobiologic approach to quantitative plant nutrition. Here we see that soybean, corn, and sugar beet are each being nourished (on separate but simi-

lar plots) by the same quantities, b units, of soil nitrogen and are using identical quantities of nitrogen to produce different yields of dry substance.

Consider then the perpendicular line P erected on the horizontal axis at p, which intersects the three curves at the points where they have flattened and the three crops are giving the maximum yields that are possible under the circumstances of the case. Here we see that, even to the end, the three species give different yields from the same quantities of soil nitrogen.

Nitrogen is one of several essential plant nutrients. In place of nitrogen we may repeat the operation with phosphate or potash, and with any other kinds of crops, and we shall see the same relationships repeated: Different kinds of plants require identical quantities of any particular plant nutrient or any combination of plant nutrients to produce maximum yields or proportional parts of these maximum yields. The resulting differences of yield are directly proportional to the quantities of life possessed by the species in question and have no dependence on the soil as such. That is the meaning of the factor c in the yield equation.

The immediate bearing of this principle on the practical art of plant nutrition is that all plants, regardless of their frequently enormously different abilities to produce vegetable substance, are comparably nourished by the same quantity of a plant nutrient. Otherwise expressed: It takes just as much nitrogen, phosphorus, potassium, etc. to produce a maximum yield of one crop as of any other crop. Or to put it another way: All soils of normal maximum fertility have identical composition in regard to the common plant nutrients.

It should be understood that this simple relation between plants and the mineral factors of their nutrition holds only in healthy, normal soils; this relation can be disturbed by any one of a host of hostile factors.

Perfertile Soil, Perultimate Yield

To understand the full scientific and social-economic import of the law of yield requires further consideration of the quantity A. (2)

As the fertility of the soil is improved by increases in the amount of a deficient factor x, the yield y approaches a maximum, Am. It may occur that besides x another factor z is deficient. If both deficiencies are repaired, a higher maximum yield, An, may be approached. Referring again to Fig. 1, let it be supposed that after the operations with nitrogen that resulted in the three continuous curves, A_1, A_2, A_3, it is discovered that the soil is also deficient in potash. A quantity of potash is incorporated in the original soil and the operation of increasing the nitrogen component is repeated with the same three species. Under the stimulus of additional potash, all three crops respond with greater yields at every stage and trace the three broken-line yield curves. These new curves are homologous with the first ones; they lie higher in the diagram and approach greater maximum yields, A_4, A_5, A_6. As other deficiencies of the soil are discovered and made good, the curves will again move higher up.

Here is an agrobiologic progression to excite scientific curiosity. To what final limit does A approach when all deficiencies of the soil have been made good? The problem here posed transcends the gratification of scientific curiosity. The future and indeed the present welfare of the human race hangs heavily on the final location of A. When breeders have produced crop plants with the largest possible quantity of life, and when the agronomists and the soil experts have learned how to evoke the full quantity of this life in the fields, man will have at his disposal the maximum quantity of food and materials for clothing that he can possibly produce on his arable land. Man may well pray that when the final limit of A has been determined it will

be found to lie so high that he can satisfy to the full not only his immediate needs but also the needs of oncoming generations far into the future. But if the ultimate productivity of land turns out to be little above what farmers are now obtaining, man must continue to face a Malthusism that has already involved much of the earth's people.

To this vastly important problem the law of yield provides a positive answer, and the answer is encouraging.

In this connection it should be kept in mind that since it is impossible to produce an unlimited amount of vegetable substance on a unit area of land in one growth cycle, only a limited amount of the factors of plant growth need be assembled on that area. In other words, it is necessary only to make the soil just rich enough to evoke all the life there is in the plants. A perfertile soil (a soil of maximum necessary fertility) being a physical (non-living) concept, it must have definite parameters which may be expressed in concrete numbers. The Mitscherlich yield equation affords a means of deriving these parameters.

For this purpose the differential equation given above is transformed into its logarithmic form

$$\log (100 - y) = 2 - 0.301 \cdot x$$

in which 100 represents 100% of any value of *A;* the numeral 0.301 reduces the values of all the specific effect factors c of all growth factors to a common denominator, and x is measured in a new kind of unit as will presently appear. The graph of this equation is shown in Fig. 2 when x is assigned successive numerical values 1, 2, 3, 4, etc.

The first point of interest in Fig. 2 is the ordinate corresponding to $x = 1$. This ordinate crosses the curve at the point that represents exactly half (50%) of the total possible yield. That is to say, one unit (x_1) of any growth factor is sufficient to produce one half (50%) of the yield that any kind of plant can produce on any normal soil whether perfertile or subperfertile. Then note that as x is increased by multiple units along the horizontal axis the curve merges with its asymtote when the soil contains about 8 units of x, which correspond to 99.61% of the maximum possible yield under the circumstances of the case.

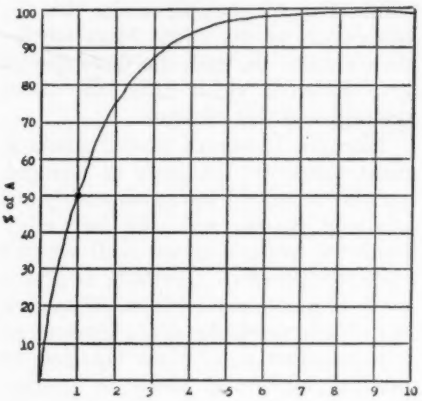

Fig. 2. Units of growth factor. Graph of the Mitscherlich-Baule form of the yield equation: $\log (100 - y) = 2 - 0.301 \cdot x$.

This description of the Mitscherlich-Baule yield curve may be condensed in the statement that there is a certain quantity of any growth factor (x) that will produce half (50%) of the maximum possible (*perultimate*) yield of any kind of crop. This quantity of growth factor is called the Baule unit, or simply the *baule*, of that growth factor. While one baule will produce half of the total effect, the action of the law of diminishing returns is such that 7 additional baules are required to bring the yield up to 99.61%. From there on it is a matter of experimental routine to ascertain the value of the baule of any factor of plant growth, whether warmth, light, water, carbon dioxide, or any chemical plant nutrient. For instance, the baule of nitrogen has been found to be 223 pounds to the acre, of phosphoric acid (P_2O_5) 45 pounds.

Thus one condition for attaining the maximum productivity of land is to furnish the soil and its surroundings

with at least *8 baules of every factor of plant growth*, taking care, of course, to exclude all hostile influences. A soil thus furnished is a perfetile soil.

To that point did Mitscherlich uncover the meaning of his yield equation. He performed the priceless service of determining the parameters of a perfertile soil. But he did not arrive at a measure of the decisive factor in the maximum productivity of land. That decisive factor is the inner capability—the quantity of life—of the plant itself, to which the fertility of the soil is at most ancillary.

To repeat: There are enormous differences in the yielding abilities of many crop plants; yet no matter how great may be the quantities of life possessed by different species the same perfertile soil will impartially assist every one of them to attain its perultimate yield. Since on a perfertile soil every kind of plant has access to the same quantity of any growth factor, or rather is exposed to the same nutrition pressure from every growth factor, the differences in yield must come from differences in the abilities of the plants to avail themselves of the same quantities of growth factors available to them.

The Nitrogen Constant 318

But how does it come about that sugar beet can accept the nutrition pressure of one baule of soil nitrogen and produce more vegetable substance than corn, and corn more than soybean, when the roots of all are bathed by the same soil solution in which the concentration of nitrogen is one baule?

We may approach this question by way of one or the other of two hypotheses. Either the sugar beet draws more heavily on the one baule of nitrogen and thus can fabricate more nitrogenous protoplasm with which to effect the synthesis of more nonnitrogenous plant substance than corn or soybean or they all draw equally on the one baule of nitrogen and all fabricate the same amount of protoplasm, the differences in yield being accounted for by differences in the specific activities of the protoplasms of the three species for synthesizing nonnitrogenous plant substance.

The inverse yield-nitrogen law leaves us in no doubt as to which hypothesis to accept. This law is to the effect that the yields of plant species are inversely as their percentage contents of nitrogen. Applying this to our three species, the nitrogen of soybean averages around 2.3%, corn 1.25%, sugar beet 0.80%. The average yields of total dry substance of these crops under normal conditions are inversely in that order. As the nitrogen percentage comes down, the total yield goes up, and vice versa.

Some if not most wheat breeders are aware of this principle; they find it impossible to obtain new varieties that under normal conditions will have more protein (nitrogen) in the grain and give more bushels to the acre than the parent strains. The breeders of sugar beets encounter a similar difficulty. The yield of sugar cannot be genetically increased without an inverse change in the nitrogen percentage of the whole plant. (*Cf.* the EE, E, N, Z, and ZZ strains of beets.)

The upshot of the yield-nitrogen law is that no matter how much or how little dry substance they produce, all crop plants remove identical amounts of nitrogen from the soil. That is to say, when different kinds of plants are cultured on a unit area of the same normal soil the product of their gross yields multiplied by their percentage contents of nitrogen is a constant. It is now a matter of finding the value of this constant in pounds of nitrogen per acre which all plants resorb from the soil when they have deployed their full quantity of life on an acre of perfertile soil. For this we turn again to the Mitscherlich-Baule form of the yield equation (3) which we now write as

$$\log (100 - y) = 2 - 0.122.x$$

Here 0.122 is the specific effect factor of the growth factor nitrogen, and in this form the equation describes the

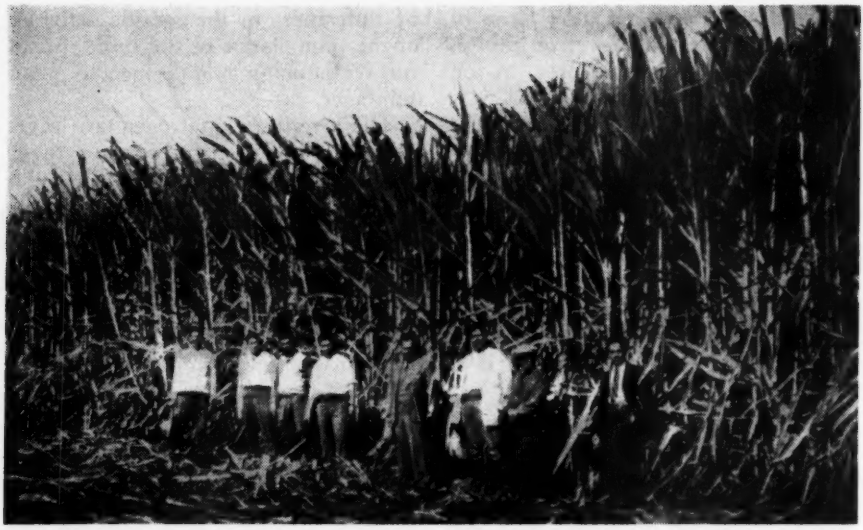

Fig. 3. Part of a field of 12 months' old POJ 2878 cane at the Ingenio de Calipam, Mexico. The yield of 147.1 tons of millable stalks per acre contained enough carbohydrate material to make 14,720 pounds of protein, which would be sufficient to supply the protein needs of 259 persons for one year. For comparison, a 20-bushel average yield of wheat would meet the annual protein needs of only 3 persons.

irreversible mass action (nutrition pressure) of soil nitrogen upon the plants. When rearranged to

$$x = \frac{2 - \log\ (100 - y)}{0.122}$$

x now represents the quantity of nitrogen that has passed out of the soil into the tissues of the plants, and it turns out to be 356 kilograms (hectare basis) or 318 pounds (acre basis).

The inexorable fact that it is impossible to produce an unlimited amount of vegetable substance on a unit area of land in one growth cycle now begins to concretize in definite numbers. We obtain the information that any kind of plant grown at the agrobiologic maximum density of stand can metabolize, in one growth cycle on one acre of normal perfertile soil, 318 pounds of soil nitrogen, and no more. These 318 pounds of nitrogen represent about 2,000 pounds of protein to the acre, and they have a twofold significance.

First, it is evident that nature has placed a definite limit on the direct production of protein on a unit area of land. Since protein is indispensable in the nutrition of man and since every person must have a minimum daily supply of protein, the natural law which fixes the amount of protein that can be produced also fixes a limit on the number of persons who can subsist on the produce of one square mile of arable land. The sociologists, the population experts, the politico-economists and the planners for a more comfortable world may carry on from there.

Secondly, the common possession of a quantitatively identical proteinous base is fair presumptive evidence that all rooted and green-leaved plants have been derived from one original stock, the "protophyte." However, the new evidence lies not so much in the fact that this base amounts to 2,000 pounds as it does in the complicated but very neatly balanced system of mass nutrition pressure which nature has organized in the same fashion for all plants. It will be recalled that one baule of any plant nutrient exerts exactly as much nutrition pressure as any other,

and that it takes the combined pressures of somewhat more than 8 baules of every factor to force the plants to complete the fabrication of their allotted base. A perfertile soil, as a natural instrument for the complete nutrition of plants, has a very definite stoichiometric structure (fixed amounts and proportions of all nutrients). It is the common subjection of all plants to this marvelously proportioned agrobiologic mass action system that is among the best evidence of their common kinship.

The outstanding fact in the present-day world of plants is that while they are all on the same footing as regards the amount of protein they can synthesize, they differ enormously in their abilities to synthesize nonnitrogenous substance. Their gross yields are the sums of their nitrogenous and nonnitrogenous substances, and by virtue of the inverse yield-nitrogen law are equal to their percentages of nitrogen divided into the agrobiologic nitrogen constant 318.

We are now in a position to address the question raised in connection with Fig. 1: To what final upper limit does A approach? In the cases of our three representative crops the calculated perultimate yields (limit values of A) are as shown in Table 1.

This series shows the enormous effect of decreasing nitrogen percentage on the value of A. So far as this writer knows the lowest percentage of nitrogen in a major crop plant is 0.285 in the sugar cane variety POJ 2878, which has a calculated perultimate yield of 111,579 lbs./acre and has been known to yield more than 140 tons of fresh millable stalks.

TABLE 1. PERULTIMATE YIELDS OF SOYBEAN, CORN, SUGAR BEET.

Crop	% of nitrogen in dry substance (whole plant)	Perultimate yield of dry substance, lbs./acre
Soybean....	2.60	A = 318/0.026 = 12,230
Corn.....	1.20	A = 318/0.012 = 26,500
Sugar beet..	0.80	A = 318/0.008 = 39,740

Note. There are appreciable differences in the nitrogen percentages of different varieties of these species; the figures are for median varieties.

And More to Come?

However, it is by no means certain that POJ 2878 with its low nitrogen and great yield is the last word on the maximum productivity of land. POJ 2878 is merely the latest in a succession of varieties that have been bred to contain smaller percentages of nitrogen and greater quantities of life; a similar succession has been found with corn and the sugar beet (4). In general, while discovery of the inverse yield-nitrogen law and the agrobiologic nitrogen constant 318 have put plant breeders on notice that it is hopeless to expect the creation of new varieties that will produce more than about 2,000 pounds of protein to the acre in one growth cycle, they are also informed that if they want greater yields of nonnitrogenous vegetable substance they have only to set about lowering the nitrogen percentage of their breeding stock. The breeders of such crops as wheat cannot conveniently take advantage of this because they must maintain a high percentage of protein in the grain. The breeders of carbohydrate-rich crops are not necessarily under this limitation, and it is in this department that we find crop plants with the largest quantities of life.

So it turns out that we are not yet in a position to say, definitely, what is the ultimate limit on the productivity of land. We must wait and see how far the breeders may go in reducing the nitrogen percentages of their new varieties. POJ 2878 now has 0.285%. Suppose that the breeders come up with a new variety with 0.1% of nitrogen; we would then have $318/0.001 = 318{,}000$ pounds of dry substance per acre. Even 0.1 may not be the lowest possible percentage of nitrogen for a normally functioning plant. Here is a wide open

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Corn Reflects Potash Supply

By N. C. Smith

Soils Department, University of Missouri, Columbia, Missouri

As our soil fertility declines, the problem of producing corn of both high quality and yield is of increasing importance. In an effort to meet this problem, fertilizer is being widely used. New methods in its application are changing its usage, especially on summer-growing crops. The amount applied is still governed by economic considerations as well as undeterminable plant needs.

Lime deficiency has become well recognized as one need that must be satisfied. Phosphorus also is accepted widely as a soil treatment. In the greater removal of other elements of fertility as influenced by these additions of lime and phosphate, potassium is the first that should receive more consideration. The advent of lespedeza as a summer crop in our already exploitive cropping systems makes the need for additional potassium more apparent.

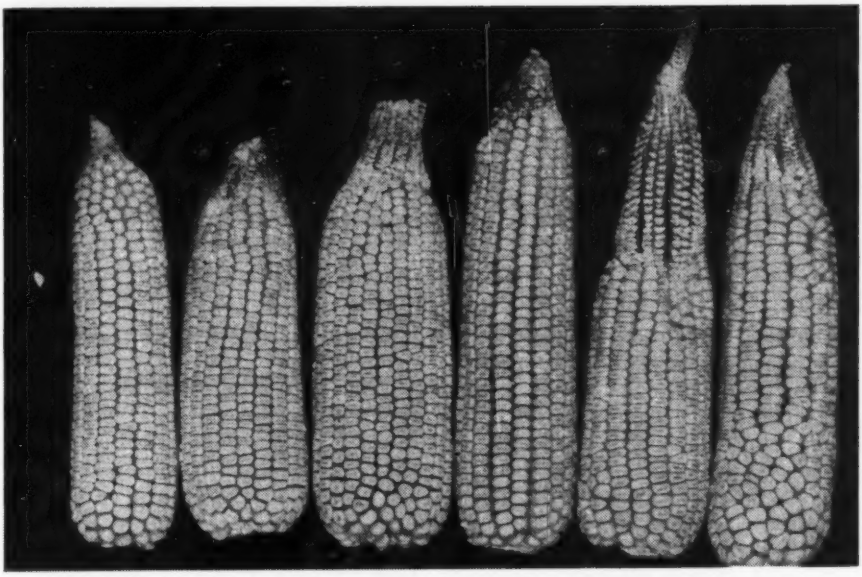
An experiment was established at the Missouri Station in 1936, using a 4-year rotation with lespedeza as the legume, with all the forages removed for hay. Deficiency symptoms pointing to the potassium as in question were soon apparent in the lespedeza plants, especially in the drier seasons. During the summer of 1947 these were especially severe on the lespedeza in this rotation. These symptoms appeared on the plants growing on the plots fertilized with potash, as well as on the plots given no potash.

It seemed possible that lack of magnesium might be the cause of the plant irregularities, rather than the lack of potassium. As a result, a fertilizer test was carried out to determine by alternative applications whether potassium or magnesium was the specific deficiency. The two elements, potassium and magnesium, were applied as salts in solution on separate small areas of the plots. Another area was included where no nutrients were added. Instead of fertilizer additions, the plants were shaded there as a means of reducing the rate of photosynthesis and of lessening the incidence of any deficiency in the fertility needed for this performance.

On the shaded area the deficiency symptoms manifested by the plant leaves disappeared entirely and they disappeared only partially from the potash-treated plants. No change could be observed in the plants on the magnesium-treated area. These observations indicated that potassium was the major limiting nutrient element or the one causing the deficiency symptoms in the lespedeza plants.

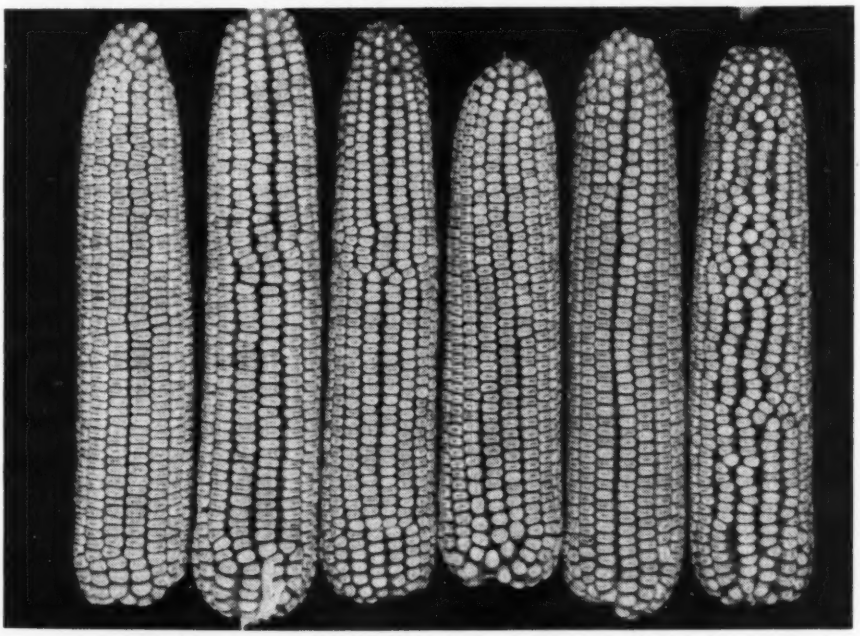
Corn was the crop following in 1948. It was given the same soil management as in previous years. The corn on the small area which had received the special application of the potassium solution on the lespedeza in 1947 was conspicuous for its greater growth and vigor from the early stages onward during the season.

Because of the continued differences in plant growth, numerous plant-tissue tests were made throughout the summer months. These tests showed a high potassium content at all times in the plants growing on the potash-treated soil. In the corn growing adjacent to this area, the tissue test did not show this abundance of potassium and at



Above: **Potash-deficient corn following sick lespedeza that was not treated with potash.**

Below: **Potash-rich corn following sick lespedeza that was treated with potash.**



times indicated very low potassium content.

Tests also indicated the soil's supply of potassium available on the two areas according to the data in Table I for sample taken July 13, 1948:

At harvest time representative one-

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Potassium in the Oregon Soil Fertility Program

By R. E. Stephenson

Soils Department, Oregon State College, Corvallis, Oregon

PLANTS require a relatively large amount of potassium for growth and high production. The bulk of the potassium in the plant is in the form of inorganic salts and is not, so far as is known, built into organic tissue as part of the physiology of the plant. Potassium in the plant, therefore, appears to have chiefly a regulatory function, common to all catalysts. No other element in the soil can take the place of potassium in the functions which it serves, not even sodium which is nearest potassium in its properties.

Potassium is most abundant in the young and growing tissues of the plant. in the buds, young leaves, root tips, and other growing parts. There is little in the woody portion. Potassium salts are relatively soluble and are easily moved from the older to the younger tissue as plant growth progresses. The older, lower leaves suffering from potassium deficiency will contain little of the element because the potassium has been moved out to points where it is most needed.

Potassium Has Several Important Functions in the Plant

Potassium is especially important in the manufacture of carbohydrates. It functions in the change of sugar to starch and in the reconversion of starch to sugar. It is necessary also for the plant to transport the sugar from one part to another. Proteins cannot be synthesized, and therefore there can be no growth without the presence of potassium. In potassium deficiency cells may elongate, but they do not divide, a process which is necessary for growth to occur.

When present in the soil in combination with nitrate, the potassium moves into the plant readily, furnishing both the potassium and the nitrogen needed for growth. Nitrate must be reduced after entering the plant to form an amino acid, and the amino acids combine to form proteins. Potassium is necessary for the reduction of the nitrate, which appears to take place soon after the nitrate enters the root system.

Potassium has been credited with stiffening the straw of small grains and with imparting disease resistance to plants. Since abundance of potassium favors carbohydrate synthesis, and the thickness of the cell wall depends upon abundant synthesis of cellulose and hemicelluloses, which are deposited on the cell wall, the stiffer straw and greater disease resistance would appear to be the natural consequence of an adequate supply of potassium.

Potassium Deficiency May Be Observed in the Plant Foliage

Potassium deficiency results in stunted plants that turn brown and dry up prematurely. The older leaves show the deficiency first, due to the tendency for the limited supply of potassium to move to the growing points and thus maintain life in the plant. Likewise, the tendency of potassium to move to the growing tips in deficiency causes a slender weak growth without much enlarging in diameter, which should occur simultaneously with elongation in a well-nourished plant. Seeds may

not mature or are small in size due to the incapacity of the plant to manufacture food for storage where potassium is lacking.

Potassium deficiency is especially noticeable in the behavior of the leaves, which first show marginal scorch and necrotic spots. The leaves also are usually contorted and cupped or puckered in shape. Finally the older leaves die or may drop prematurely. By contrast, well-nourished leaves of most crops are flat, smooth, and dark green, exposing their surfaces to the sunlight to utilize the sun's energy for manufacturing carbohydrate.

Crops frequently respond to potassium with increased growth when there are no visible symptoms of deficiency in the unfertilized plants. Other deficiencies and also excesses of some elements produce symptoms that closely resemble potassium deficiency. For these reasons visible symptoms are not always reliable for diagnosing the need for potassium fertilization unless the observer is experienced. A field trial if only on a few rows or even on a few plants is a safer test for the need for potassium.

The Potassium Requirement of Plants Is High

Although all crops require considerable potassium, those grown for their sugar or starch, such as potatoes and sugar beets, may have a higher requirement. Crops which make big yields of vegetative growth, such as alfalfa with three cuttings in a season, also take much potassium from the soil. Some of the vegetables, cabbage, lettuce, spinach, celery, and others, have rather high requirements.

When available potassium is abundant, plants are guilty of "luxury consumption," which means that they take in more potassium than is necessary for growth because it is readily available, or because of some other uncorrected nutrient deficiency which leads to an unbalanced nutrition of the plant. Potassium contents as high as 7 per cent in tobacco, clover, lettuce, and sugar beet leaves and 9 per cent in spinach, young corn, and cabbage leaves have been reported. On the other hand, lows of less than 1 per cent are frequently found where there is a deficiency. The percentage found depends in part upon the age of the plant and the portion of the plant analyzed. Young plants are likely to be richer in potassium, and the foliage usually contains more than other parts.

The Potassium Content of the Soil Varies

Perhaps the most important original source of potassium in the soil was orthoclase feldspar, which contains 14 per cent of the element. The potassium content of the soil is governed in part by the type of material from which the soil was formed. Shale formations usually contain more than twice the potassium found in sandstone formations, and the potassium content of soils of any large area would vary according to the formation from which they were derived. Lava rocks are relatively high in potassium and are likely to weather down to produce high-potassium soils.

The average good soil varies in potassium content from 1 to 1½ per cent, with peats and sandy soils running quite low, while some of the best soils have nearly twice this amount. A large portion of the potassium in the soil is insoluble and unavailable to plants. Another portion is slowly available as the crop roots make contact with moist soil surfaces. A small part is in solution in the soil moisture and, of course, readily available to crops. The clay fraction of the soil holds considerable potassium and the sand comparatively little. The heavier textured clayey soils are therefore likely to be best supplied with potassium.

Humus Renewal Improves Potassium Availability

Adequate humus renewal is important in maintaining available potassium

in the soil. Since vegetative materials that go to make humus may carry relatively large quantities of this plant food, which is liberated in the soil, these materials themselves contribute available potassium. The rotting organic materials produce solvents and carriers of potassium that are effective in improving the potassium nutrition of the plant.

Some Oregon Soils Are Deficient in Potassium

Present knowledge indicates that Oregon soils are generally well-supplied with potassium, except for the peaty areas, sandy soils, and some old strongly-leached formations. A large portion of the potassium is fairly readily available to growing crops. On most of the farming area, therefore, there is no acute shortage.

Use of fertilizers in Oregon is confined to Western Oregon soils or to special crops in Eastern Oregon. The muriate is the principal form of potassium used, either as such or as part of a complete mixture. Other elements, particularly nitrogen and sometimes phosphorus, sulfur, or boron, are so much more limiting factors in plant growth that response to potassium is unlikely unless these other deficiencies are first corrected.

On Aiken clay loam, an old leached soil, a cover crop of barley and vetch showed an increased growth of 162 per cent from nitrogen alone, 218 per cent from nitrogen and sulfur, and 324 per cent from nitrogen, sulfur, and phosphorus. When muriate of potash at the rate of 200 pounds an acre was added to the nitrogen, phosphorus, and sulfur, the yield increase was 384 per cent. This was from liberal rates of fertilization. The essentiality of correcting nitrogen or other severe deficiencies before response could be expected from additional treatments is indicated by an increase of only 9 per cent in yield from phosphorus alone compared to 106 per cent gain over nitrogen and sulfur from phosphorus added to a nitrogen and sulfur combination.

All Limiting Deficiencies Must Be Corrected

In greenhouse studies where it was attempted to supply sufficient nutrients for maximum growth by adequately correcting all deficiencies, use of potassium always gave added growth, even on the best soils, if other deficiencies were first corrected. These results indicate that lack of response to any particular added nutrient element might be due not so much to an adequacy of that element as to a deficiency of some other element which so limited growth that no other treatment was of any avail until the one or more major deficiencies were corrected.

In some early work on samples of soil taken at considerable depth using sunflower as an indicator plant, boron was so deficient that the plants nearly refused to grow with or without other treatments until the boron deficiency was first corrected. When boron was provided, there was a nice response to the regular treatment supplying the necessary nutrient elements, and growth became satisfactory. In another trial with lima beans, the yield with boron added to N-P-K-S was nearly doubled over that of the N-P-K-S alone, indicating that boron was a rather severe limiting factor in fertilizer response.

Horticultural Crops Respond to Liberal Fertilization

The experiment station in recent years has given special study to the fertilizer program for horticultural crops of which Oregon produces a great variety. On all such crops as vegetables, small fruits, gladioli, daffodils, and lilies, a complete fertilizer including the N-P-K-S formula is recommended. On some soils and for some crops, boron must be added to the above formula. Every deficiency

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Fig. 1. Pendleton Farmers' Society Hall, erected 1826-28, is claimed to be the oldest such building in the United States. Begun as a courthouse for old Pendleton District, it was not completed because the District was divided into three counties and Pendleton was not a suitable location for any courthouse. The Pendleton Society took it over and made it into the building as it now appears, using the upper floor as a regular meeting place continuously since that time. The lower floor has been in use for many years as a U. S. Post Office.

Some Farming Societies and Farming Science

By A. B. Bryan

Clemson, South Carolina

IN South Carolina for more than a century farmers' societies have played an important role, through the intelligent leadership of their members, in the promotion of better farming ideas and practices. The relation between the work of these farm groups and the advancement of farming science is direct and evident.

One of these societies—the Charleston Agricultural Society—is the second oldest farmers' society in the United States. This society, officially the Agricultural Society of South Carolina, was organized in the fall of 1785 and is therefore only a few months junior to the Philadelphia Society for the Promotion of Agriculture, which was organized February 11, 1785.

Another of these South Carolina farmers' societies, the Pendleton Farmers' Society, is the fourth oldest in the Nation, having been organized in 1815, and is therefore antedated by the Massachusetts Society for the Promotion of Agriculture, which came into being in 1792.

Two other century-old South Caro-

lina farmers' groups are the Darlington Agricultural Society and the Beech Island Farmers' Society, both organized in 1846. Several other such groups in the State are 60 to 80 years old. All are still active and efficient agencies in promoting farming science and improved practices.

Lighting the Way

A hundred and fifty years or even a hundred years is no brief period in the life of a State or Nation. It is a long time in the life of a voluntary organization, such as these farmers' clubs, held together not by necessity but by a desire to serve their members and the public in the common good. Their age is some proof that they have filled a real need in the agricultural, economic, and social life of their sections. They have remained true in principle and are still dedicated to their original purpose as typified in the words of the constitution of the Pendleton Farmers' Society—"The object of the society shall be the promotion and improvement of agriculture and rural affairs."

A noteworthy thing in the records of these groups is the clear and unmistakable idea of independence of thought and action and a spirit of self-help and courage as well as fine group cooperation. A farmer discovering a new method or technique did not hide the light of his discovery under a bushel; he revealed it gladly to his fellow farmers, offering them the benefit of his experience.

Another noteworthy fact about these organizations is the able and distinguished men among their officers and members. Just to illustrate: In the Charleston Society there were Thomas Heyward, a signer of the Declaration of Independence; John Rutledge, a Chief Justice of the Nation, and others. In the Beech Island Society one example is James Henry Hammond, governor and U. S. Senator and originator of the term "King Cotton." In the Darlington Society examples are Chancellor G. W. Dargan and Governor David Rogerson Williams. In the Pendleton Society were Thomas Pinckney, Jr., John C. Calhoun, and Thomas G. Clemson.

These and many other notables of early and later years in these groups were not only jurists, statesmen, soldiers, and civic leaders but also *farmers*, to whom farmers of today owe much in the arts of farming and even in the science underlying. For example again: St. Julien Ravenel of Charleston is responsible for developing the phosphate beds around Charleston and the process of making ammoniated fertilizer. Calhoun of Pendleton was first to advocate and practice hillside ditching against erosion and subsoil plowing. Of Clemson of Pendleton we shall have more to say later as a promoter of science in farming and the need of agricultural education.

These four farmers' societies, in short, have rendered long and honorable service to their members and to the public welfare. And their interests are still primarily agricultural and educational. They represent, in fact, about the first organized efforts in agricultural education, as we shall see. Furthermore, these societies have helped to develop many leaders in science and education, because they have encouraged their members to conduct trials and experiments, offered premiums for superior products, agitated for better agricultural training, and even purchased and deeded land to the State for agricultural experimentation.

We must forego the temptation to tell in detail what these several farmers' societies have done to advance the art and science of farming and confine ourselves chiefly to some account of the Pendleton Farmers' Society and of one of its members in particular who has loomed large in the field of agricultural science.

We pause briefly, however, to say a word about how the Darlington Society has advanced the knowledge of cotton farming especially. Darlington is the heart of South Carolina's great Pee Dee section, a rich cotton-

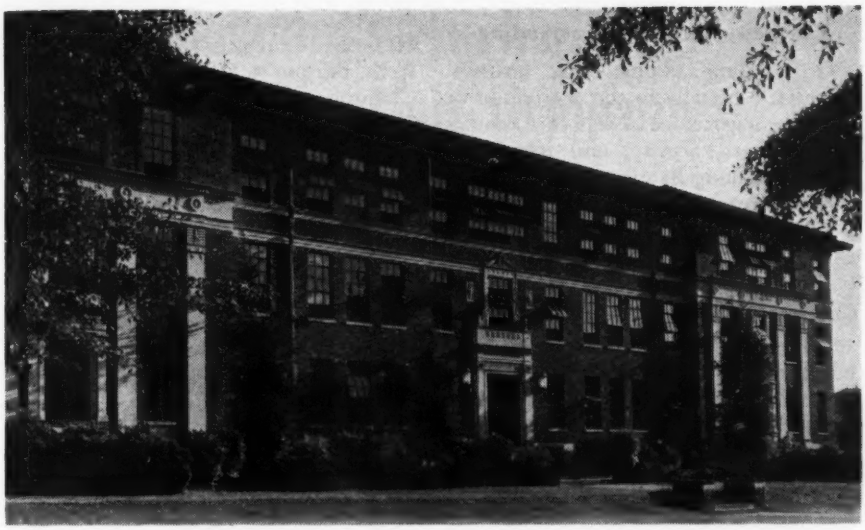

Fig. 2. The W. W. Long Hall at Clemson College, headquarters of the agricultural teaching, research, and extension activities of the institution founded on the Calhoun estate by Thomas G. Clemson.

producing area in the Coastal Plain of the State. It is but natural, therefore, that members of this group should study to improve cotton production. Throughout its hundred-year history they have worked efficiently toward finding through research and practice a knowledge of cotton that proved to be forerunner of things wrought later by the agricultural experiment stations in scientific research. These include:

Development of better varieties or strains of cotton.

Early know-how on spacing cotton plants for maximum yields and better lint.

Pioneering use of lime or marl, Peruvian guano, and commercial fertilizer.

Unsurpassed records for cash returns from cotton per acre.

Methods of fighting the boll-weevil and other cotton pests.

Establishment of local cotton factories and oil mills to process lint and seed.

Chancellor Dargan's championing of the value of commercial fertilizer, be it said, was at the risk of ridicule, for some of his friends are said to have warned: "You are a fool to use that stuff; it will ruin your land and bankrupt you."

This Darlington Society, recognizing the importance of agricultural education, urged in 1869 "training in practical agriculture and mechanic arts" as the Pendleton Society had done some two years earlier. A resolution unanimously passed by the Darlington Society said:

"Resolved: That one of the most pressing wants of the State at the present time is the establishment of institutions of learning for our youth, in connection with training in practical agriculture and the mechanic arts as will enable pupils by their own industry to defray the expenses of their education.

"Resolved: That the establishment of such an institution under the care and patronage of the South Carolina Agricultural and Mechanical Society would be one of the surest and most effective means of developing and promoting the material interest of the State, and giving intelligence, respectability, and efficiency to labor in its most important department."

Pendleton Society Outstanding

Outstanding among these farmers' societies, especially in the promotion of farming science, has been the Pendleton Farmers' Society, and most conspicuous among its many notable members on preaching the gospel of science as the basis of real progress in agriculture and rural life was Thomas Green Clemson, founder of Clemson College.

The Pendleton Farmers' Society, established in the village of Pendleton in 1815, was promoted and fostered by leading men of education and culture who were farmers in the surrounding area. Many of them were low-country plantation owners from the Charleston area who were summer residents, a number of whom became permanent residents. They were thinkers as well as doers in the field of farming.

Early leaders included Thomas Pinckney, Jr., the society's first president. The early and mid-century rolls included many important names: Andersons, Adgers, Cherrys, Hugers, Hunters, Porchers, Pickenses, Maxwells, Simpsons, Calhouns, Thomas G. Clemson, and others.

John C. Calhoun, South Carolina's great statesman of the Calhoun-Clay-Webster era, was president of the society in 1839. Thomas G. Clemson, son-in-law of the great Calhoun, was president in 1866 and for two decades a powerful influence in its affairs.

The Society's Scientific Spirit of Inquiry

The records of the Pendleton Society offer ample evidence through the years of its scientific spirit of inquiry and experimentation. Some of this evidence we present as briefly as possible.

A report of the Committee on Grasses in 1818 discusses among other things—"Dog foot" or orchard grass, *dactylis glomerata*—found valuable for grazing. "Lucerne (alfalfa to us), which has been found very valuable for soiling. A gentleman of great responsibility sowed a quarter of an acre

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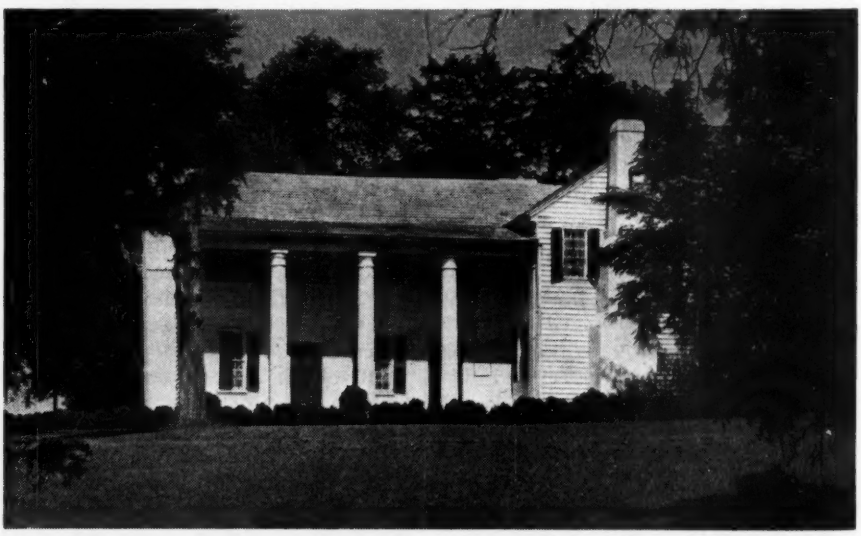

Fig. 3. Historic Fort Hill, home of John C. Calhoun for many years until his death in 1850, was later the home of Thomas G. Clemson from 1872 until his death in 1888. Located in the heart of the Clemson College campus in sight of Tillman Hall, the Administration Building of the College, it was restored jointly by the College authorities and the John C. Calhoun Chapter, United Daughters of the Confederacy, and has been kept as a Calhoun-Clemson shrine.

Vermont's Agricultural Conservation Program

By Thomas H. Blow

Production and Marketing Administration, U. S. Department of Agriculture, Burlington, Vermont

SIX hundred ACP farmer committeemen serve Vermont's 26,490 * farms scattered throughout the length and breadth of the State's 14 counties. This means that for every 45 to 50 farms one committeeman is available to give assistance to the farm operator for a better understanding of the Agricultural Conservation Program and thus direct the various practices which it offers.

That a "back to the grass roots" plan serves Vermont farmers well is evidenced by the strong farmer participation in the program down through the years. 'Tis true that the number taking part in the various practices fluctuates from year to year, but this is to be expected in such a program.

Vermont is a small State, and agriculture provides its major source of income. The 1945 census shows 95,000 people living on farms, or approximately 1 out of every 4 persons in the State directly dependent on the farm operator for a living.

The Vermont Agricultural Conservation Program has grown into a strong organization. It has done so because it has built the program around a community's needs as known by the committeeman who is right back at the grass roots. With 600 committeemen and 188 communities, the rural areas are being well served by the community committee system as it now operates.

Down through the years Vermont has been very proud of its record of ACP cooperation with other agencies. Very close relations have always existed between the Agricultural Conservation Program and the Vermont Agricultural Extension Service, which has been responsible for much of the publicity and education in Extension and ACP work. The county agent in several of the counties also has used the conservation practices as the basis of his soils and crops program.

Use of Materials

Lime—The use of lime, one of the basic needs of the State's soils and crops, has grown from a low of 3,500 tons in 1936 to a high of 118,000 tons in 1944. In 1944 it was supplied at no direct cost to the farmer.

While this increase may seem quite favorable, the amount now used is still a far cry from the estimated amount needed. Based on acreage, the cropland requiring lime totals 1,200,000 acres. In addition, 400,000 acres of non-crop pasture show the same need. Assuming that one ton of lime should be applied every four years, the annual need in such a rotation becomes 500 lbs. per acre per year, as a maintenance application for the State's 1,600,000 acres of cropland and non-crop pasture.

Superphosphate—With superphosphate the trend is much the same —from a low of 3,300 tons prior to the start of the program to over 50,000 tons during the war years. Even today, the tonnage of super used will be 10 times that used before the program got under way.

Superphosphate usage is based on the

* Census figure used. For all practical purposes, the number of actual farm units in the State is usually considered to be approximately two-thirds of the census figure.

need for a 300-pound-per-acre application annually to cover an initial and maintenance need of the State's 1,478,000 acres of pasture, new seedings, and the present hay stand acreage.

Potash—It has been necessary to depend on the use of complete fertilizer or such grades as 0-14-14 or 0-20-20 to supply potash through the program. Only in a couple of earlier years was a straight potash payment practice available to the farmer. This is unfortunate because soil tests, sound land use, and crop needs in practically every county point to a very definite potash deficiency. In some counties, such as Caledonia in the northeastern part of the State, the need for potash has been shown by soil tests to be as great as the need for phosphorus. However, through the medium of mixed grades, it has been possible partially to meet the potash needs through the use of the program and thus assist materially in converting a greater acreage to legume roughage and improved pasture throughout the State.

In breaking down the State acreage, we find 483,000 acres of total pasture, 60,000 acres of new seedings of grasses or legumes, and 650,000 acres of hay. To satisfy the crop needs on these 1,193,000 acres, it is estimated that an average annual application of 150 lbs. of muriate of potash per acre for initial and maintenance needs should take care of the potash requirements. This represents a total annual need of 89,475 tons annually.

Under the 1949 program a small start will be made in supplying some of the much needed potash, because of a special allotment of some 8,500 tons of 0-14-14. This will, however, be only a very small proportion of the amount really needed for maximum roughage production throughout the State.

Public Relations Program

In January of this year the Vermont State Committee approved a 1949 public relations program that would tie in at least once each month with some important phase of the State's agriculture. The monthly meetings scheduled by the Committee call for the following subject matter presentations throughout the year:

1. Public relations (Over-all Program).
2. Milk marketing.
3. Marketing agreements.
4. Price levels, parity, and price support.
5. Cooperation with State Department of Agriculture and a meeting with the Commissioner of Agriculture.
6. Meeting with representatives of Grange and Farm Bureau.
7. Meeting with representatives of the Extension Service.
8. Research and Marketing Administration meeting.
9. Agricultural research meeting, including PMA and land use.
10. Poultry and turkey marketing.
11. Forestry and its products.
12. Vermont Development Commission.

To these meetings the Committee invites members of the University and State Agricultural College and Experiment Station, Soil Conservation Service, State Department of Agriculture and Forest Service, Department of Education, State Farm Bureau, Grange, Vermont Development Commission and Vermont Cooperative Council, etc. As a result of this broad program, the State PMA hopes to reach such groups as agricultural organizations, milk companies, feed dealers, veterans, labor organizations, bankers' association, credit agencies, chambers of commerce, the rural church, the schools, all the various inter-related agencies and, in particular, the individual.

Looking Ahead

Vermont's program is a long-time program. It is based on the agricul-

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The county agent plays a major part in the Vermont soils and roughage program. Roger Whiteomb, County Agent, Orleans County, discusses "Better Crops" with Vermont's Senator Aiken.

Soil tests provide a guide to better soil management. Dr. A. R. Midgley in the Soils Laboratory, University of Vermont.

In the early days of Vermont's "ACP" program, county, state, and national leaders met to draft plans at the State level.

Vermont Committeemen keep posted on ACP work in other states. The Caledonia County farmer committeemen visit Maine.

The farmer committee system at work in Vermont results in spirited meetings to consider urgent problems.

A typical Vermont farm setting where the Committeeman serves the folks of his community in program cooperation.

Vermont's hills and valleys provide a variety of roughage and grazing for its "more cattle than people."

Cows and milk are the Vermont farmer's major sources of income. Soils must be strong to maintain the dairy industry.

The Editors Talk

What Is Required of a Program?

The editorial policy of this magazine is expressed in our slogan—"The Whole Truth—Not Selected Truth"—a policy which we trust is recognized by our readers. Under this policy, the editors have no inclination to deal in their own comments on controversial subjects, that prerogative being left to our contributors.

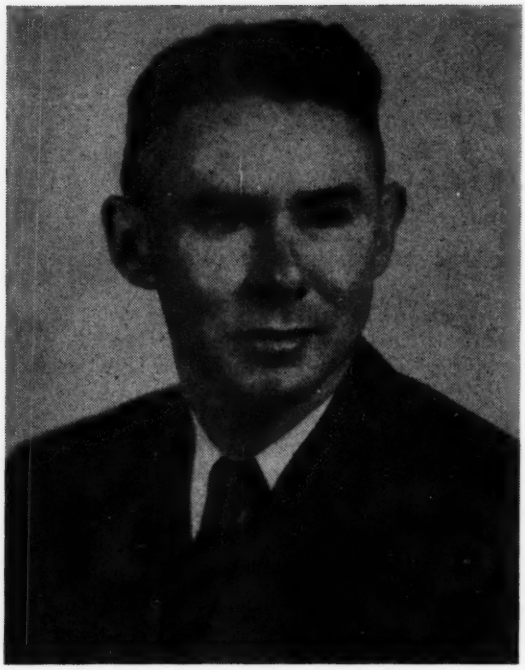
Accordingly, in presenting the following excerpts from the statement of Secretary of Agriculture Charles F. Brannan at a joint hearing of the House Committee on Agriculture and the Senate Committee on Agriculture and Forestry, we adhere to this policy. Nevertheless, we are confident that the quotations to follow will be universally recognized as The Truth, impressively stated, regardless of what the Congress within its prerogatives may think, say, and do with respect to the Brannan program for agricultural stabilization. The requirements for a program were eloquently stated. It is our hope that they will inspire our legislators and their advisers to provide the Nation with basic agricultural laws which will effect the fulfillment of these requirements:

"First, the program must effectively serve the farmer and his family. As an isolated individual, the farmer has no control over the prices he will receive, and no adequate way of adjusting the total market volume of his commodities to changing demand. After he has planted a crop, he is at the mercy of weather, price, and many other forces with which he is powerless to cope. On many occasions in the past, he has labored all season and produced a good crop only to find that, because of circumstances beyond his control, his labor would go uncompensated and sometimes his cash investment in seed, fertilizer, and other operating costs would be only partially recovered. A program to help him meet those basic difficulties is the very minimum for which we should strive.

"Second, in serving the farmer the program must not discriminate unfairly against any group. It should be fair to consumers and to processors, shippers, wholesalers, retailers, and others in the distribution system. There is no real conflict between farmers and either consumers or business people. The customers of agriculture want plentiful and steady supplies, and they have a right to expect that a program supported by the public will help meet this need. Farmers want to furnish plentiful supplies regularly.

"Third, the program must be efficiently operated and the cost must be commensurate with the benefits to the Nation.

"Fourth, it must serve general policy objectives, including national security, the maintenance of high-level employment, and cooperation with other nations in the interests of peace and prosperity. It can do this by conserving and strengthening our basic productive resources, providing reserves against national emergencies, and encouraging free-flowing world trade by reasonably assuring sufficient products for export."



J. FIELDING REED

THE American Potash Institute is pleased to announce the appointment of Dr. J. Fielding Reed as manager of its Southern territory, the position left vacant upon the election of Dr. H. B. Mann as president. Dr. Reed will assume his duties on July 1 with offices in the Mortgage Guarantee Bldg., Atlanta, Ga.

A native of Louisiana, Dr. Reed attended the Louisiana State University, receiving a B.S. degree in chemical engineering in 1933, his M.S. in 1934, and a Ph.D. degree in 1937. In 1939-40 he held a Rockefeller Foundation post-doctorate fellowship at Cornell University. Returning to L. S. U., he served as Assistant Agronomist and Professor of Soils until 1942 when he accepted a position as Agronomist with the North Carolina Department of Agriculture and North Carolina State College. For two years he was in charge of soil fertility investigations with peanuts and in 1948 was co-winner of the $1,000 award of the National Peanut Council for contributions to the peanut industry. He has been teaching courses in soil fertility and soil chemistry at N. C. State College and his research in the field of soil chemistry has included studies of the importance of type of colloid considerations and the effect of cation-exchange properties of the soil on the cation uptake and composition of plants. Since July 1948, he has been Director of the Soil-testing Division of the N. C. Department of Agriculture as well as Professor of Agronomy at N. C. State College.

Dr. Reed is a member of the Soil Science Society of America, American Society of Agronomy, American Chemical Society, American Association for the Advancement of Science, and the American Society of Plant Physiologists. His fraternities include Sigma Chi, Alpha Chi Sigma, Sigma Xi, Phi Kappa Phi, and Tau Beta Pi, and he is a member of Lion's International.

He is married to Olive Mae MacDonald of Reserve, Louisiana, and they have two daughters—Martha, age 11, and Jeannie, 7.

The Farmer Holds the Key

Agricultural workers in laboratory, classroom, and field investigations will do well to bear constantly in mind that the farmer himself is the KEY MAN in agricultural improvements.

The fruits of agricultural research are only of academic interest if the farmer does not avail himself of them. No matter how excellent the medicine, it effects no cure if the patient fails to take it.

Season Average Prices Received by Farmers for Specified Commodities *

Crop Year	Cotton Cents per lb.	Tobacco Cents per lb.	Potatoes Cents per bu.	Sweet Potatoes Cents per bu.	Corn Cents per bu.	Wheat Cents per bu.	Hay Dollars per ton	Cottonseed Dollars per ton	Truck Crops
	Aug.-July	.....	July-June	July-June	Oct.-Sept.	July-June	July-June	July-June	....
Av. Aug. 1909–July 1914....	12.4	10.0	69.7	87.6	64.2	88.4	11.87	22.55	....
1924.....	22.9	19.0	68.6	149.6	106.3	124.7	12.66	33.25	....
1925.....	19.6	16.8	170.5	165.1	69.9	143.7	12.77	31.59	....
1926.....	12.5	17.9	131.4	117.4	74.5	121.7	13.24	22.04	....
1927.....	20.2	20.7	101.9	109.0	85.0	119.0	10.29	34.83	....
1928.....	18.0	20.0	53.2	118.0	84.0	99.8	11.22	34.17	....
1929.....	16.8	18.3	131.6	117.1	79.9	103.6	10.90	30.92	....
1930.....	9.5	12.8	91.2	108.1	59.8	67.1	11.06	22.04	....
1931.....	5.7	8.2	46.0	72.6	32.0	39.0	8.69	8.97	....
1932.....	6.5	10.5	38.0	54.2	31.9	38.2	6.20	10.33	....
1933.....	10.2	13.0	82.4	69.4	52.2	74.4	8.09	12.88	....
1934.....	12.4	21.3	44.6	79.8	81.5	84.8	13.20	33.00	....
1935.....	11.1	18.4	59.3	70.3	65.5	83.2	7.52	30.54	....
1936.....	12.4	23.6	114.2	92.9	104.4	102.5	11.20	33.36	....
1937.....	8.4	20.4	52.9	82.0	51.8	96.2	8.74	19.51	....
1938.....	8.6	19.6	55.7	73.0	48.6	56.2	6.78	21.79	....
1939.....	9.1	15.4	69.7	74.9	56.8	69.1	7.94	21.17	....
1940.....	9.9	16.0	54.1	85.5	61.8	68.2	7.58	21.73	....
1941.....	17.0	26.4	80.7	94.0	75.1	94.4	9.67	47.65	....
1942.....	19.0	36.9	117.0	119.0	91.7	110.0	10.80	45.61	....
1943.....	19.9	40.5	131.0	204.0	112.0	136.0	14.80	52.10	....
1944.....	20.7	42.0	149.0	192.0	109.0	141.0	16.40	52.70	....
1945.....	22.5	36.6	143.0	204.0	127.0	150.0	15.10	51.10	....
1946.....	32.6	38.2	122.0	218.0	156.0	191.0	16.70	71.90	....
1947.....	31.3	38.0	156.0	215.0	235.0	241.0	17.30	85.40	....
1948									
April.....	34.10	31.2	209.0	240.0	219.0	229.0	19.40	89.40	....
May.....	35.27	40.1	196.0	244.0	216.0	222.0	18.30	90.70	....
June.....	35.22	41.7	187.0	246.0	216.0	211.0	17.90	92.20	....
July.....	32.99	43.6	166.0	262.0	202.0	203.0	18.20	96.00	....
August.....	30.41	47.4	158.0	265.0	191.0	196.0	17.80	76.60	....
September...	30.94	46.7	153.0	232.0	178.0	197.0	18.00	68.10	....
October.....	31.07	50.6	142.0	207.0	138.0	198.0	18.40	63.70	....
November....	30.52	42.8	144.0	198.0	121.0	204.0	18.40	69.00	....
December....	29.63	45.7	154.0	219.0	123.0	205.0	19.10	68.80	....
1949									
January.....	29.27	42.9	166.0	236.0	125.0	202.0	19.80	65.70	....
February.....	29.14	29.5	172.0	244.0	112.0	194.0	20.50	53.40	....
March.....	28.74	31.9	174.0	254.0	118.0	198.0	20.00	51.40	....
Index Numbers (Aug. 1909–July 1914 = 100)									
1924.....	185	190	98	170	166	141	107	147	143
1925.....	158	168	245	188	109	163	108	140	143
1926.....	101	179	189	134	116	138	112	98	139
1927.....	163	207	146	124	132	135	87	154	127
1928.....	145	200	76	134	131	113	95	152	154
1929.....	135	183	189	133	124	117	92	137	137
1930.....	77	128	131	123	93	76	93	98	129
1931.....	46	82	66	83	50	44	73	40	115
1932.....	52	105	55	62	50	43	52	46	102
1933.....	82	130	118	79	81	84	68	57	91
1934.....	100	213	64	91	127	96	111	146	95
1935.....	90	184	85	80	102	94	63	135	119
1936.....	100	236	164	106	163	116	94	148	104
1937.....	68	204	76	93	81	109	74	87	110
1938.....	69	196	80	83	76	64	57	97	88
1939.....	73	154	100	85	88	78	67	94	91
1940.....	80	160	78	97	96	77	64	96	111
1941.....	137	264	116	107	117	107	81	211	129
1942.....	153	369	168	136	143	124	91	202	163
1943.....	160	405	188	232	174	154	125	231	245
1944.....	167	420	214	219	170	160	138	234	212
1945.....	181	366	205	232	198	170	127	227	224
1946.....	263	382	175	249	212	209	141	319	204
1947.....	252	380	224	245	366	273	146	379	249
1948									
April.....	275	312	300	273	341	259	163	396	340
May.....	284	401	281	278	336	251	154	402	262
June.....	284	417	268	280	336	239	151	409	213
July.....	266	436	238	298	315	230	153	428	213
August.....	245	474	227	302	298	222	150	340	172
September...	250	467	220	264	277	223	152	302	150
October.....	251	506	204	236	215	224	155	282	176
November....	246	428	207	226	188	231	155	306	186
December....	239	457	220	250	192	232	161	305	209
1949									
January.....	236	429	238	269	195	229	169	291	282
February.....	235	295	249	279	174	219	173	237	285
March.....	232	319	250	290	184	224	168	228	263

Wholesale Prices of Ammoniates

	Nitrate of soda bulk per unit N	Sulphate of ammonia bulk per unit N	Cottonseed meal S. E. Mills per unit N	Fish scrap, dried 11–12% ammonia, 15% bone phosphate, f.o.b. factory, bulk per unit N	Tankage 11% ammonia, 15% bone phosphate, f.o.b. Chicago, bulk, per unit N	High grade ground blood, 16–17% ammonia, Chicago, bulk, per unit N
1910–14	$2.68	$2.85	$3.50	$3.53	$3.37	$3.52
1924	2.99	2.44	5.87	5.02	3.60	4.25
1925	3.11	2.47	5.41	5.34	3.97	4.75
1926	3.06	2.41	4.40	4.95	4.36	4.90
1927	3.01	2.26	5.07	5.87	4.32	5.70
1928	2.67	2.30	7.06	6.63	4.92	6.00
1929	2.57	2.04	5.64	5.00	4.61	5.72
1930	2.47	1.81	4.78	4.96	3.79	4.58
1931	2.34	1.46	3.10	3.95	2.11	2.46
1932	1.87	1.04	2.18	2.18	1.21	1.36
1933	1.52	1.12	2.95	2.86	2.06	2.46
1934	1.52	1.20	4.46	3.15	2.67	3.27
1935	1.47	1.15	4.59	3.10	3.06	3.65
1936	1.53	1.23	4.17	3.42	3.58	4.25
1937	1.63	1.32	4.91	4.66	4.04	4.80
1938	1.69	1.38	3.69	3.76	3.15	3.53
1939	1.69	1.35	4.02	4.41	3.87	3.90
1940	1.69	1.36	4.64	4.36	3.33	3.39
1941	1.69	1.41	5.50	5.32	3.76	4.43
1942	1.74	1.41	6.11	5.77	5.04	6.76
1943	1.75	1.42	6.30	5.77	4.86	6.62
1944	1.75	1.42	7.68	5.77	4.86	6.71
1945	1.75	1.42	7.81	5.77	4.86	6.71
1946	1.97	1.44	11.04	7.38	6.60	9.33
1947	2.50	1.60	12.72	10.66	12.68	10.46
1948						
April	2.78	1.90	13.87	11.71	12.75	8.35
May	2.78	1.90	13.77	9.54	12.75	7.89
June	2.78	1.90	14.69	9.11	8.23	8.24
July	2.78	2.07	14.56	9.22	8.80	8.73
August	2.91	2.10	10.91	9.76	8.92	8.98
September	3.00	2.20	10.70	9.87	9.18	9.03
October	3.00	2.20	9.31	9.98	9.41	9.48
November	3.00	2.20	11.00	10.31	10.44	10.68
December	3.00	2.20	11.52	11.65	11.39	11.46
1949						
January	3.15	2.23	10.29	8.68	11.53	11.53
February	3.19	2.27	9.44	12.36	10.78	10.70
March	3.19	2.27	9.27	12.36	9.64	11.46
Index Numbers (1910-14 = 100)						
1924	111	86	168	142	107	121
1925	115	87	155	151	117	135
1926	113	84	126	140	129	139
1927	112	79	145	166	128	162
1928	100	81	202	188	146	170
1929	96	72	161	142	137	162
1930	92	64	137	141	12	130
1931	88	51	89	112	63	70
1932	71	36	62	62	36	39
1933	59	39	84	81	97	71
1934	59	42	127	89	79	93
1935	57	40	131	88	91	104
1936	59	43	119	97	106	131
1937	61	46	140	132	120	122
1938	63	48	105	106	93	100
1939	63	47	115	125	115	111
1940	63	48	133	124	99	96
1941	63	49	157	151	112	126
1942	65	49	175	163	150	192
1943	65	50	180	163	144	189
1944	65	50	219	163	144	191
1945	65	50	223	163	144	191
1946	74	51	315	209	196	265
1947	93	56	363	302	374	297
1948						
April	104	67	396	332	378	237
May	104	67	393	270	378	224
June	104	67	420	258	244	234
July	104	73	416	261	261	248
August	109	74	312	276	265	255
September	112	77	306	280	272	257
October	112	77	266	283	279	269
November	112	77	314	292	310	303
December	112	77	329	330	338	326
1949						
January	118	78	294	246	342	328
February	119	80	270	350	320	304
March	119	80	265	350	286	326

Wholesale Prices of Phosphates and Potash * *

	Superphosphate Baltimore, per unit	Florida land pebble 68% f.o.b. mines, bulk, per ton	Tennessee phosphate rock, 75% f.o.b. mines, bulk, per ton	Muriate of potash bulk, per unit, c.i.f. Atlantic and Gulf ports[1]	Sulphate of potash in bags, per unit, c.i.f. Atlantic and Gulf ports[1]	Sulphate of potash magnesia, per ton, c.i.f. Atlantic and Gulf ports[1]	Manure salts bulk, per unit, c.i.f. Atlantic and Gulf ports[1]
1910–14	$0.536	$3.61	$4.88	$0.714	$0.953	$24.18	$0.657
1924	.502	2.31	6.60	.582	.860	23.72	.472
1925	.600	2.44	6.16	.584	.860	23.72	.483
1926	.598	3.20	5.57	.596	.854	23.58	.537
1927	.525	3.09	5.50	.646	.924	25.55	.586
1928	.580	3.12	5.50	.669	.957	26.46	.607
1929	.609	3.18	5.50	.672	.962	26.59	.610
1930	.542	3.18	5.50	.681	.973	26.92	.618
1931	.485	3.18	5.50	.681	.973	26.92	.618
1932	.458	3.18	5.50	.681	.963	26.90	.618
1933	.434	3.11	5.50	.662	.864	25.10	.601
1934	.487	3.14	5.67	.486	.751	22.49	.483
1935	.492	3.30	5.69	.415	.684	21.44	.444
1936	.476	1.85	5.50	.464	.708	22.94	.505
1937	.510	1.85	5.50	.508	.757	24.70	.556
1938	.492	1.85	5.50	.523	.774	15.17	.572
1939	.478	1.90	5.50	.521	.751	24.52	.570
1940	.516	1.90	5.50	.517	.730	24.75	.573
1941	.547	1.94	5.64	.522	.780	25.55	.367 [1]
1942	.600	2.13	6.29	.522	.810	25.74	.205
1943	.631	2.00	5.93	.522	.786	25.35	.195
1944	.645	2.10	6.10	.522	.777	25.35	.195
1945	.650	2.20	6.23	.522	.777	25.35	.195
1946	.671	2.41	6.50	.508	.769	24.70	.190
1947	.746	3.05	6.60	.498	.706	18.93	.195
1948							
April	.760	4.11	6.60	.375	.669	14.50	.200
May	.760	4.61	6.60	.375	.669	14.50	.200
June	.760	4.61	6.60	.330	.634 [1]	12.76 [1]	.176
July	.770	4.61	6.60	.353	.676	13.63	.188
August	.770	4.61	6.60	.353	.678	13.63	.188
September	.770	4.61	6.60	.353	.678	13.63	.188
October	.763	4.61	6.60	.375	.720	14.50	.200
November	.770	4.61	6.60	.375	.720	14.50	.200
December	.770	4.61	6.60	.375	.720	14.50	.200
1949							
January	.770	4.61	6.60	.375	.720	14.50	.200
February	.770	4.61	6.60	.375	.720	14.50	.200
March	.770	3.85	7.06	.375	.720	14.50	.200
Index Numbers (1910-14 = 100)							
1924	94	64	135	82	90	98	72
1925	110	68	126	82	90	98	74
1926	112	88	114	83	90	98	82
1927	100	86	113	90	97	106	89
1928	108	86	113	94	100	109	92
1929	114	88	113	94	101	110	93
1930	101	88	113	95	102	111	94
1931	90	88	113	95	102	111	94
1932	85	88	113	95	101	111	94
1933	81	86	113	93	91	104	91
1934	91	87	110	68	79	93	74
1935	92	91	117	58	72	89	68
1936	89	51	113	65	74	95	77
1937	95	51	113	71	79	102	85
1938	92	51	113	73	81	104	87
1939	89	53	113	73	79	101	87
1940	96	53	113	72	77	102	87
1941	102	54	110	73	82	106	87
1942	112	59	129	73	85	106	84
1943	117	55	121	73	82	105	83
1944	120	58	125	73	82	105	83
1945	121	61	128	73	82	105	83
1946	125	67	133	71	81	102	82
1947	139	84	135	70	74	78	83
1948							
April	142	114	135	68	70	60	83
May	142	128	135	68	70	60	83
June	142	128	135	62	67	53	80
July	144	128	135	65	71	56	82
August	144	128	135	65	71	56	82
September	144	128	135	65	71	56	82
October	142	128	135	68	76	60	83
November	144	128	135	68	76	60	83
December	144	128	135	68	76	60	83
1949							
January	144	128	135	68	76	60	83
February	144	128	135	68	76	60	83
March	144	107	145	68	76	60	83

Combined Index Numbers of Prices of Fertilizer Materials, Farm Products and All Commodities

	Farm prices*	Prices paid by farmers for commodities bought*	Wholesale prices of all commodities†	Fertilizer material‡	Chemical ammoniates	Organic ammoniates	Superphosphate	Potash**
1924.....	143	152	143	103	97	125	94	79
1925.....	156	156	151	112	100	131	109	80
1926.....	146	155	146	119	94	135	112	86
1927.....	142	153	139	116	89	150	100	94
1928.....	151	155	141	121	87	177	108	97
1929.....	149	154	139	114	79	146	114	97
1930.....	128	146	126	105	72	131	101	99
1931.....	90	126	107	83	62	83	90	99
1932.....	68	108	95	71	46	48	85	99
1933.....	72	108	96	70	45	71	81	95
1934.....	90	122	109	72	47	90	91	72
1935.....	109	125	117	70	45	97	92	63
1936.....	114	124	118	73	47	107	89	69
1937.....	122	131	126	81	50	129	95	75
1938.....	97	123	115	78	52	101	92	77
1939.....	95	121	112	79	51	119	89	77
1940.....	100	122	115	80	52	114	96	77
1941.....	124	131	127	86	56	130	102	77
1942.....	159	152	144	93	57	161	112	77
1943.....	192	167	151	94	57	160	117	77
1944.....	195	176	152	96	57	174	120	76
1945.....	202	180	154	97	57	175	121	76
1946.....	233	202	177	107	62	240	125	75
1947.....	278	246	222	130	74	362	139	72
1948								
April.....	291	264	238	137	85	380	142	71
May.....	289	265	239	137	85	370	142	71
June.....	295	266	241	128	85	309	142	65
July.....	301	266	247	231	88	317	144	68
August....	293	266	247	129	91	285	144	68
September.	290	265	247	131	94	287	144	68
October...	277	263	243	130	94	277	142	72
November.	271	262	239	134	94	311	144	72
December .	268	262	237	137	94	336	144	72
1949								
January...	268	260	233	136	97	313	144	72
February..	258	257	231	136	99	309	144	72
March.....	261	258	231	134	99	290	144	72

* U. S. D. A. figures. Beginning January 1946 farm prices and index numbers of specific farm products revised from a calendar year to a crop-year basis. Truck crops index adjusted to the 1924 level of the all-commodity index.

† Department of Labor index converted to 1910-14 base.

‡ The Index numbers of prices of fertilizer materials are based on original study made by the Department of Agricultural Economics and Farm Management, Cornell University, Ithaca, New York. These indexes are complete since 1897. The series was revised and reweighted as of March 1940 and November 1942.

[1] All potash salts now quoted F.O.B. mines only: manure salts since June 1941, other carriers since June 1947.

**** The weighted average of prices actually paid for potash is lower than the annual average because since 1926 over 90% of the potash used in agriculture has been contracted for during the discount period. Since 1937, the maximum discount has been 12%. Applied to muriate of potash, a price slightly above $.471 per unit K_2O thus more nearly approximates the annual average than do prices based on arithmetical averages of monthly quotations.**

REVIEWS

This section contains a short review of some of the most practical and important bulletins, and lists all recent publications of the United States Department of Agriculture, the State Experiment Stations, and Canada, relating to Fertilizers, Soils, Crops, and Economics. A file of this department of BETTER CROPS WITH PLANT FOOD would provide a complete index covering all publications from these sources on the particular subjects named.

Fertilizers

"Sales of Commercial Fertilizers and of Agricultural Minerals Reported to Date for Quarter Ended December 31, 1948," Bu. of Chem., State Dept. of Agr., Sacramento 14, Calif., FM-177, Feb. 17, 1949.

"Supplemental List Commercial Fertilizers Registrants for the Fiscal Year Ending June 30, 1949 (Issued subsequent to list of December 15, 1948)," Bu. of Chem., State Dept. of Agr., Sacramento, Calif., FM-178, Mar. 17, 1949.

"Supplemental List Agricultural Minerals Registrants for the Fiscal Year Ending June 30, 1949 (Issued subsequent to list of December 16, 1948)," Bu. of Chem., State Dept. of Agr., Sacramento, Calif., FM-179, Mar. 18, 1949.

"Commercial Fertilizers Inspected and Analyzed in the State of Georgia, Year 1948," State Dept. of Agr., Atlanta, Ga., Serial No. 133, Jan. 1949.

"More Nitrogen for Sugar Cane," La. Agr. Exp. Sta., Unno. mimeo., Feb. 1949, V. E. Green, D. S. Byrnside, and M. B. Sturgis.

Soils

"Save Your Soil," Ext. Serv., Kans. State College, Manhattan, Kans., Cir. 204, June 1948, R. C. Lind and H. B. Harper.

"Gravel Culture for Growing Ornamental Greenhouse Crops," Agr. Exp. Sta., Wooster, Ohio, Res. Bul. 679, Dec. 1948, D. C. Kiplinger and Alex Laurie.

"Suggestions for Improving Slick-spot Soils," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Bul. B-329, Feb. 1949, H. J. Harper and M. J. Plice.

"Soil Moisture and Wheat Yields on the High Plains," U.S.D.A., Washington, D. C., Leaf. 247, H. H. Finnell.

"Manage Farm Ponds for Bass and Bluegills," Soil Conservation Service, U.S.D.A., Washington, D. C., P. A. 65, 1948.

"Conservation and Use of Agricultural Land Resources," Prod. and Mktg. Admin., U.S.D.A., Washington, D. C., Jan. 1949.

Crops

"Growth and Diseases of Guar," Agr. Exp. Sta., Univ. of Ariz., Tucson, Ariz., Bul. 216, July 1948, R. L. Matlock and D. C. Aepli.

"Home Vegetable Gardening," Agr. Ext. Serv., Univ. of Calif., Berkeley, Calif., Cir. 26, Rev. Nov. 1948, J. H. MacGillivray.

"Vegetable Growing," Div. of Horticulture, Central Exp. Farm, Dominion Dept. of Agr., Ottawa, Ont., Can., Publ. 816, Farmers' Bul. 154, Oct. 1948, W. Ferguson.

"Oat and Rye Recommendations for Northern Florida for 1948-1949," Agr. Exp. Sta., Univ. of Fla., Gainesville, Fla., Press Bul. 653, Sept. 1948, S. C. Litzenberger, W. H. Chapman, and W. A. Carver.

"Winter Clovers for South Florida Flatwoods," Agr. Exp. Sta., Univ. of Fla., Gainesville, Fla., Press Bul. 654, Sept. 1948, E. M. Hodges, D. W. Jones, and W. G. Kirk.

"Pimiento Production in Georgia," Exp. Sta., Univ. System of Ga., Experiment, Ga., Bul. 259, March 1949, F. F. Cowart and A. H. Dempsey.

"Agricultural Research in Idaho," Agr. Exp. Sta., Univ. of Idaho, Moscow, Idaho, Bul. 270, A. R. 55, July 1948.

"Protein in Open-Pollinated and Hybrid Corn," Dept. of Agron., Agr. Exp. Sta., Univ. of Ill., Urbana, Ill., AG 1340, Aug. 1947, H. J. Snider.

"Three Years of Sunflower Seed Production in Piatt County, Illinois," Dept. of Agron., Agr. Exp. Sta., Univ. of Ill., Urbana, Ill., AG 1341, Sept. 1947.

"Spring Oats," Dept. of Agron., Agr. Exp. Sta., Univ. of Ill., Urbana, Ill., AG 1355, Feb. 1948, J. F. Rundquist, G. H. Dungan, and O. T. Bonnett.

"Ladino Clover," Dept. of Agron., Agr. Exp. Sta., Univ. of Ill., Urbana, Ill., AG 1358, Mar. 1948, R. F. Fuelleman.

"Pasture Renovation," Dept. of Agr. Ext., Div. of Agron., Purdue Univ., Lafayette, Ind., AY #112 (Rev.), 1948.

"Requirements for Seed Potato Production and Certification," Ext. Serv., Univ. of Md., College Park, Md., Bul. 119, May 1948, R. A. Jehle.

"1948 Extension Work in Minnesota," Agr. Ext. Serv., Univ. of Minn., St. Paul 1, Minn., A. R. 1948.

"Lespedeza," Ext. Serv., Miss. State College,

State College, Miss., Ext. Agron. Folder No. 5, Feb. 1949, W. R. Thompson.

"Science Serving Agriculture," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Part I, Biennial Rpt., 1946-48.

"Science Serving Agriculture," Agr. Exp. Sta., Okla. A & M College, Stillwater, Okla., Part II, Biennial Rpt., 1946-1948.

"Fall Gardening," Ext. Serv., Okla. A & M College, Stillwater, Okla., Cir. 486, E. L. Whitehead.

Economics

"Land Tenure in the Southwestern States—A Summary of Significant Findings of the Regional Land Tenure Research Project," Agr. Exp. Sta., Univ. of Ark., Fayetteville, Ark., Bul. 482, Oct. 1948.

"Ventura County Citrus Orchard Management Study—Valencia Oranges and Lemons, 1947," Agr. Ext. Serv., Univ. of Calif., Berkeley, Calif.

"Economic Aspects of Farm Pastures in the Mississippi River Delta Cotton Area of Louisiana," Agr. Exp. Sta., La. State Univ., Baton Rouge, La., Mimeo. Cir. 85, Sept. 1948, A. R. Cheshire and F. D. Barlow, Jr.

"Farm Property Ownership and Disposition of Estates in Maryland," Ext. Serv., Univ. of Md., Bul. 121, Sept. 1948, G. M. Beal.

Vermont's Agricultural Conservation Program

(*From page* 26)

tural historical background of the State. The farmer of today knows all too well that the Vermont hills and valleys have seen the era of beef cattle and sheep come and go. He has seen in recent years what has happened to the production of butter as a source of income and he has seen many times how meager were the returns from other side lines in the developing of his business. With 85 per cent or more of the Boston milkshed supplies of milk coming from Vermont, and with current prices for his product in a good relationship with production costs, the Vermont farmer should be and is vitally concerned with what is ahead.

The Extension Service is in a strong position to do the educational job that is so necessary in our present-day economy. With it, along with the help of such agencies as the Production and Marketing Administration through its community and county committee system to assist in the field, much material help can be given in maintaining the agricultural production of the State.

There is no desire, nor should there be, on the part of any one agency to do all that needs to be done. Rather, the situation calls for making the best use of those "tools" that have been provided by our nation's foremost thinkers in giving to agriculture a more satisfying rural life, and the maintaining and improving of "that top six inches of soil." These are absolutely necessary, if our states and nation are to continue strong.

Some Farming Societies

(*From page* 24)

on a stiff red clay hill—this was well manured—and in common years he has cut it seven times, but this last summer being unusually seasonable, it was cut nine times and kept six horses."

To stimulate active discussion and accumulate information, the Society at its meeting September 8, 1819, listed a hundred queries on which members were urged to write their experiences and opinions. A score of these will show the wide range of inquiry:

Have you ever used ashes as a manure?

Have you ever applied lime to your land?

Do you know anything of marl?

How deep ought lands to be plowed?

Do you fallow your land?

Do you lay your fields in ridges or lands?

What is the best method of fattening cattle?

Do you know the disorder in cattle called milk sick?

What breeds of hogs are best?

What are the causes of smut, mildew, and blast? The remedies?

Do our soils and climate suit barley?

What grasses make best pasture? What best hay?

What facts have you on cultivation and value of lucerne, clover, orchard grass?

Cannot some of our native grasses be improved by culture?

What kind of apples afford best cider?

What is the best method of grafting, inoculating, and planting orchards?

How do you destroy moles?

Have you any improvement in management of bees?

In the 1840's, the records show, the Pendleton Society made an effort "to introduce silk culture. Cocoons might be found in an outhouse of nearly every home, and Multicaulis trees, the leaves of which were to supply food for the silkworms, were rapidly and widely set; but the venture came to naught."

On May 7, 1883, "The club met at the residence of Mr. D. K. Norris. We saw his underground drains, simply two boards nailed together and inverted. One drain, doing its work well by the copious flow of water, Mr. Norris said, had been down for five years."

A most interesting item of the Society's records is the report of a meeting in October, 1843, listing toasts proposed by members at the dinner. Some of the toasts:

W. B. Seabrook—"The cause of agriculture throughout the world."

John C. Calhoun—"Agriculture, most important but most oppressed branch of industry."

C. C. Pinckney—"The pursuit of agriculture, the most useful, most honorable, most ennobling of all pursuits."

Dr. F. W. Symmes—"Pendleton agriculture, to be improved and made profitable only by economy and manure."

O. R. Broyles—"A judicious rotation of crops, most important practice of agriculture."

F. Burt—"The agricultural survey of the State, the first recognition of farming interest by our legislative authorities."

R. F. Simpson—"South Carolina, if behind her sisters in anything it is in agriculture."

Thomas G. Clemson—"In the absence of marl, permit me to propose a more familiar acquaintance with the effects—of potash, soda, and magnesia."

A. H. Seabrook—"Commerce, manufactures, and agriculture, but the greatest of these is agriculture."

J. O. Lewis—"Marl, may it add as much energy to the men as it has added fertility to the soil."

Some 40 years later, an extract from the minutes of the meeting January 24, 1883, shows—"The club met at Mr. J. C. Stribling's place. Inspected Mr. Stribling's silo. It exhibits very satisfactory and instructive results." Stribling, practically a lifetime member of the Society, built the first silo in the South. He was a pioneer dairyman and breeder of Jersey cattle and in 1882 he sold a pedigreed Jersey cow for the then fabulous sum of $1,000.

For Agricultural Education

In many deliberations before the War Between the States the members of the Pendleton Society discussed better education and scientific training for farmers. It was as early as 1825 that "a labor school" for practical farming and mechanical work was established a few miles from Pendleton and fostered by the Society—probably the

first effort of this kind of training for farmers in the United States.

But even more definite and direct thinking and planning for education in the science of agriculture sprang up among the members of the Society immediately after the war. In 1867, Thomas G. Clemson, while president of the Society, urged the establishment of "an institution for the education of our people in the sciences," thus projecting the agitation which in time led to the establishment of what is now Clemson Agricultural College. President Clemson named a committee to appeal for funds for such an institution—R. F. Simpson, W. A. Hayne, and himself—and William Henry Trescot, another distinguished member of the society, wrote the appeal, which was widely distributed. But the time seemed not yet ripe for accomplishment.

Nevertheless, when one member of the Society in later years called the Pendleton Farmers' Society "the mother of Clemson College," he was not too wide the mark. Certainly with its Calhoun, its Clemson, its efforts to establish a farm labor school, its constant work in promoting soil improvement, better seeds, diversified crops, purebred livestock, experiments with fertilizers and new implements, and its movement toward establishing an agricultural college, the Pendleton Society has wrought worthily and well for more intelligent farming and better rural life.

Thomas Green Clemson and Clemson College

Since it is now apparent that the Pendleton Farmers' Society has always fostered educational efforts toward more intelligent and more successful farming, and that Thomas G. Clemson was the society's most outstanding protagonist for scientific training for farmers, we turn our attention to him and the birth of Clemson College.

Briefly, Thomas Green Clemson was a Pennsylvania Quaker, born in Philadelphia July 1, 1807; educated in Philadelphia, then in France in mining engineering and chemistry. Back in the United States, he met Anna Maria, daughter of John C. Calhoun and married her in 1838. A strong bond was soon established between the statesman and the scientist; and shortly the Clemsons came to South Carolina, Clemson to have supervision of farming on Calhoun's Fort Hill Plantation near Pendleton and of Calhoun's north Georgia gold-mining ventures.

Clemson's definite turn toward scientific agriculture is indicated in his toast at the Pendleton Society's dinner in 1843 on "better knowledge of mineral fertilizers," which showed his trend toward agricultural chemistry. At this time also he bought "Canebrake Farm" in Abbeville county and made his own venture into farming.

A diplomatic service career covering eight years, 1844-52, included several years as minister to Belgium. Returning to the United States in 1852, he bought a farm in Maryland, was active in promoting scientific agriculture, and was helpful in the establishment of Maryland Agricultural College. Then in 1860 he was appointed Superintendent of Agricultural Affairs, which was then an office in the Patent Office, U. S. Department of Interior; and through his work there and otherwise he had no little influence in the establishment later of the U. S. Department of Agriculture. But for war and political contingencies, he perhaps would have been the first Secretary of Agriculture in the United States.

Came the War Between the States, and Clemson cast his lot with the Confederate States, serving patriotically and efficiently as a chemist in mining engineering. Then, returning to South Carolina in 1866, the family lived in Pendleton. Clemson was soon president of the Pendleton Farmers' Society, and he began his agitation for scientific education to better the farming conditions then existing. Hear the record speak:

"January 1867: At a previous meeting held November 24, 1866, Hon. R. F. Simpson, Col. W. A. Hayne, and Hon. Thomas G. Clemson were appointed a committee to appeal for aid to found an institution for educating our people in the sciences to the end that our agriculture may be improved, our worn-out and impoverished lands be recuperated, and the great natural resources of the South be developed. —The Hon. Thomas G. Clemson addressed the Society in an interesting and a most able and instructive discourse and submitted the following appeal in the form of a circular, which by direction of the Society was printed and fully circulated both at home and abroad."

The following extracts are from the circular, which was drafted by William Henry Trescot on request of the committee:

"Considering that our lands are so impoverished by the growth and exportation of cotton that much of them will not pay the cost of cultivation, and that our agriculture generally is in a wretched condition; that legislation has failed to protect the agricultural resources of the Commonwealth from unnecessary and wholesale despoliation;—that avenues of wealth and honor are restricted for want of science, upon which the arts are based and without which civilization cannot advance; and that ignorance is the cause of our destitution and the parent of crime, misery, and death—

"We, the committee, on behalf of the Agricultural Society and our fellow citizens now make this earnest appeal to the well disposed of all classes and sects for aid to found an institution for the diffusion of scientific knowledge, that our civilization may advance and we may once more become a prosperous and happy people.

"If this our prayer meets with sufficient response, an institution will go into operation from whence science of the highest order in all its forms will be gratuitously dispensed to unborn millions. The upper region of South Carolina would appear, above all others, adapted for the location of such an institution.—

"Donations of funds, books, apparatus are earnestly solicited."—

But, sad to say, "funds, books, apparatus" were not forthcoming for this great educational dream to become a reality. Not yet; the time was not ripe.

A Dream Comes Alive

But the dream did not vanish. In 1856 Thomas G. Clemson had written: "The only hope we have for the advancement of agriculture is through the sciences." In 1869 he caused to be passed a resolution by the South Carolina Agricultural and Mechanical Society applying for U. S. Land Grant funds to establish a school for technical education. He kept on dreaming and working to make his dream come true.

In 1871 Clemson bought at a foreclosure sale the Fort Hill home and estate of John C. Calhoun, his father-in-law, who had died in 1850, and the Clemsons moved from Pendleton to Fort Hill four miles away in 1872. Upon the death of their children Calhoun Clemson and Floride Clemson in 1871, Mr. and Mrs. Clemson made plans and mutual agreements to leave their property to the people for scientific education. In 1874 Clemson offered free land on which to establish a school; but to no avail.

Mrs. Clemson died in 1875, and Thomas Clemson was left alone to brood over his dream of scientific education as "the only hope for the advancement of agriculture." Then, in the early 1880's Clemson conferred from time to time with Col. R. W. Simpson, able Pendleton lawyer, on his plans to donate the Fort Hill property and certain funds for the promotion of agricultural education. A first draft of the Clemson will would have called the school "Calhoun-Clemson College"; a second draft would have named it

"Fort Hill Scientific Institute"; the final draft, made by Col. Simpson, specified the name "The Clemson Agricultural College," at Col. Simpson's suggestion.

On December 6, 1886, Thomas G. Clemson invited to a conference Col. R. W. Simpson and Col. D. K. Norris, close friends of Clemson, and B. R. Tillman, afterwards Governor and U. S. Senator, who had taken up the agitation for better education of farmers, to discuss ideas regarding agricultural education.

At Clemson's death, April 6, 1888, Col. R. W. Simpson, who had been named one of the life trustees provided in the Clemson will, called a meeting of the seven life trustees to be held at Fort Hill May 2, 1888, to consider ways and means of carrying out the provisions of the will regarding "The Clemson Agricultural College." Through these trustees Clemson's bequest to the State was presented to the South Carolina Legislature December 4, 1888. A bill accepting the bequest was passed by the Legislature in December 1888 and was signed after considerable delay by Governor Richardson November 27, 1889.

Thus was born "The Clemson Agricultural College of South Carolina," which became in due time the Land Grant college of the State, which opened its doors to students in 1893, and which has in its 55 years of operation trained thousands of men to serve the State and the Nation and has otherwise blessed the people through teaching, research, and extension of scientific knowledge.

The thirst for knowledge and the spirit of inquiry of the historic agricultural societies and especially the Pendleton Farmers' Society, and the spirit of Thomas Green Clemson, have become the spirit of Clemson College. That spirit is the spirit of progress and service, and that spirit is marching on to bless the State, the Nation, and the world.

The motto of these societies and the motto of Thomas G. Clemson might well have been, and the motto of Clemson College might well be, the words at the base of the Statue of Liberty in New York harbor—"I lift my lamp beside the open door."

Potassium in Oregon Soil Fertility

(*From page* 20)

must be corrected and humus renewal must be provided to get best results.

A good formula for general use on average soils in horticultural crops is 500 pounds of sulfate of ammonia, 225 pounds of treble superphosphate, and 200 pounds of muriate of potash an acre. This is equivalent to 1,000 pounds of 10-10-10 an acre. On the better soils or where too much vegetative growth is undesirable, the nitrogen application may be cut down perhaps to one half the above rate. Sulfate of ammonia used as a source of nitrogen supplies adequate sulfur as well as nitrogen.

On tree fruits the need for potassium is not great and additional response from providing potassium on most orchard soils has not been demonstrated. If potassium is needed for growing the cover crop, however, its use in the orchard is probably justified. Humus renewal is so important in the orchard soil that whatever treatment will help to grow more humus material in the form of a cover crop deserves consideration.

The Potassium-Nitrogen Balance Is Important

Adequate use of potassium helps provide better balance in the nutrition of the plant. The relationship between available potassium and available nitrogen is especially important. Nitrogen

stimulates rapid growth and potassium stimulates carbohydrate production. Both nitrogen and carbohydrate are used in the formation of proteins which are essential in the growth process. Too much nitrogen leads to excessive growth and exhaustion of carbohydrate which may reduce fruiting. Lack of nitrogen for growth may result in excess of carbohydrate, and this likewise is unfavorable to fruiting. Thus is seen the importance of a favorable balance between nitrogen and potassium to produce a plant that is vigorous and fruitful but not over vegetative.

Oregon soils are more likely to be deficient in nitrogen than in potassium. Due to heavy winter precipitation, the soils come into the spring thoroughly leached of soluble nitrogen. Then comes a period of warm weather while the soil is moist and available nitrogen is produced in the soil. This is a good growth period. Soon lack of summer rains and low humidity produce a dry topsoil and nitrogen ceases to become available at an appreciable rate. Growth then slows as much from lack of available nitrogen as from lack of moisture.

Potassium Is Not Readily Lost from the Soil

Potassium is not leached as severely as the nitrogen and does not become so completely unavailable in dry weather. Therefore there is the urgent need for providing nitrogen by fertilizing at the right time so that the plant can absorb and store a nitrogen supply in its tissue to carry over the drouth period. This enables the plant to make better use of the available potassium or perhaps to respond to an application of potassium fertilizer assuming, of course, that no other limiting deficiency is present.

Some potassium is lost from the soil by leaching, but a considerable loss is by crop removal, and much of the crop removal loss is unnecessary with good management. In grain production there are 2 to 4 times as much potassium removed in the straw as in the grain. The straw should return to the soil, which would therefore return most of the potassium. In small fruit production only 4 to 8 pounds of potassium an acre are sold in the fruit with average yields. The major portion remains in the vine or foliage, which stays on the land. The sale of tree fruits takes off a little more potassium, but the major portion returns to the soil with the fall of the leaves. On the livestock farm the animal retains only about 10 per cent of the potassium in the feed. Most of the other 90 per cent should return to the soil with the manure.

Valuable Crops Need Potassium

Good management should make it possible to so conserve the potassium supply of the soil that the need for potassium fertilization is minimized. Perhaps in most cases, only crops of high acre value such as small fruits, vegetables, sugar and starchy crops, and nursery crops would need an extra potassium application. These crops are often so valuable that a little increase in yield or improvement in quality or perhaps a little increased disease resistance may justify including potassium in the fertilizer program as a means of insurance against deficiency. The more liberally fertilizer is used to force big yields, the more important the inclusion of potassium becomes. The longer land is farmed and the poorer the methods used, the greater the need for potassium fertilization to bring about improvement.

Use of Fertilizer Is Rapidly Increasing

Oregon growers are in the process of learning to use fertilizer effectively. In the 5-year period 1935-39 approximately 16,000 tons of fertilizer were used annually in the entire State. In the next 4 years the average use nearly doubled to 30,000 tons and use jumped to an average of 82,000 tons for the 2 years, 1946 and 1947. Estimates for use in 1948 run as high as 140,000 tons.

This is still a small usage compared to what might profitably be used on high-priced crops. The future will see more fertilizer, including potassium, used on Oregon farms to bring greater profits and soil improvement.

Nodules for Nitrogen in Forage Production

(*From page* 8)

Lotus plots produced nearly three times more protein than the well-fertilized grass plots. Since the protein in the legume is more digestible than that in the grass, the advantage in favor of the Lotus is even greater. (See Table IV.) The results also show that this soil is very responsive to phosphorus even for grasses, which accounts for the fact that when the same amount of nitrogen was used, a 1-1-0 ratio was better than where a smaller phosphorus ratio was used. This very high phosphorus responsive soil is the main reason that Lotus does so well and produces so much protein when limed and mineralized.

Grass Versus Legume on a Light Sandy Soil

Field experiments similar to the above were also conducted on a light sandy soil, except that brome grass was substituted for reed canary as it is better adapted to this soil. Much larger amounts of potash were also used because this light soil requires rather large amounts even for good grass development. The comparative yields and cost of fertilizing for grasses or for legumes (Lotus) are given in Table III.

Good responses were obtained from use of high-nitrogen fertilizers on grass, but the fertility cost per ton of forage

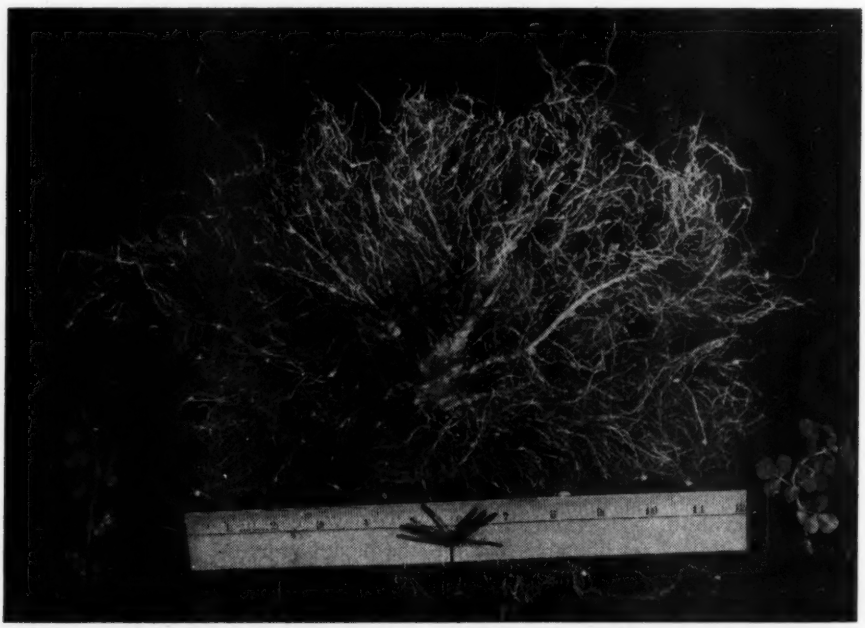


Fig. 3. Root system of a two-year-old selected broadleaf Lotus plant. Note the large, round leaves on either side and the cluster of seed pods on the rule, resembling a bird's foot.

produced was rather high on this light soil. Greater yields with higher protein content were obtained when minerals were used and a legume grown than in case of grass. The fertilizer cost was also much less. Lotus produces large amounts of nitrogen as indicated in the protein produced per acre. Lotus also produced more protein per acre than the grass plots regardless of the amount of nitrogen and fertilizer used. The fertilizer treatment containing 60 pounds of phosphoric acid (P_2O_5) and 60 pounds of potash (K_2O) produced greater yields and more protein when used on Lotus than the same amount of minerals plus 60 pounds of nitrogen when used on grass.

In these trials, 80 pounds of nitrogen per acre caused excessive lodging of grass and lower harvested yields. Usually nitrogen should not be used in excess of 60 pounds per acre, and frequently this gives trouble if grass hay is cut late. Some depressive effect resulted from use of nitrogen on the Lotus plots. This was primarily because it produced excessive grass growth which reduced the stand of Lotus.

Fig. 4. Late fall growth of a two-year-old selected broadleaf birdsfoot trefoil plant, taken from the breeding plots at the Vermont Station. The leaflets of this European type plant are large and round, but many of them had fallen off late in the year when the picture was taken. See Fig. 3 for root system.

Legumes Increase Digestible Protein

Legumes are particularly good as forage crops because they are higher than

TABLE III.—COMPARATIVE YIELD, PROTEIN CONTENT, AND FERTILIZER COST IN GROWING GRASS VERSUS LEGUME ON A SANDY SOIL.

Fertilizer lbs. per acre N–P_2O_5–K_2O	Pounds per acre		Cost of fertilizer used [1]	Fertilizer cost per ton of hay [2]
	Hay	Protein		
	(Brome Grass)			
20–20–20	1,693	169	$ 7.00	$ 8.36
40–40–40	2,265	259	14.00	12.35
60–60–60	3,511	444	21.00	11.95
80–80–80	3,295	440	28.00	17.00
	(Lotus & Brome Grass)			
0–60–30	3,796	483	7.50	3.95
0–60–60	4,838	616	9.00	3.72
0–60–60+B+Mg [3]	4,931	628	12.80	5.20
30–60–60	3,583	456	15.00	8.37

[1] Fertilizer cost based on following: nitrogen, 20¢; P_2O_5, 10¢; and K_2O, 5¢ per pound.
[2] The amount of hay produced without fertilizer was not considered here. No treatment produced 863 and 2,766 pounds respectively.
[3] Borax at 40 pounds and magnesium sulphate at 300 pounds were used per acre. The cost was figured over a 3-year period because the effect was expected to last for several years.

TABLE IV.—COMPARATIVE COST OF PRODUCING DIGESTIBLE PROTEIN WITH DIFFERENT FERTILIZERS ON GRASS VERSUS GRASS-LOTUS ON PANTON CLAY. TWO-YEAR AVERAGE, 1947-48.

Fertilizer lbs. per acre $N-P_2O_5-K_2O$	Digestible protein [1] lbs. per acre	Cost of fertilizer used [2]	Fertilizer cost per 100 lbs. of dig. protein
	(Reed Canary Grass)		
15–15–0	151	$ 4.50	$ 2.98
30–30–0	182	9.00	4.94
45–45–0	257	13.50	5.26
30–15–0	149	7.50	5.03
60–30–0	235	15.00	6.39
	(Lotus-Reed Canary)		
0–45–0	951	4.50	1.00
0–45–15	511	5.25	1.03
0–60–15	657	6.75	1.03
15–45–15	495	8.25	1.66

[1] This is based on the fact that this grass contained 4.6% digestible protein and the Lotus 10.08%. In the Lotus-grass plots there were 75% Lotus and 25% grass.
[2] For fertilizer cost see footnote in Table II.

grasses in digestible protein. Lotus is no exception. In fact, it approaches alfalfa because of its many leaves and fine stem. The amount of digestible protein produced and the fertilizer cost to produce this by using the best adapted grass or legume on a heavy clay soil are shown in Table IV.

These results show a marked advantage by using minerals and growing a suitable legume instead of grass alone. While forage plants need large amounts of nitrogen for good growth and protein production, it is advisable to obtain this nitrogen through legumes wherever possible. There is a place for legumes on every dairy farm, but one of the problems is to select the proper legume for the different soils involved. After this is done, these forage crop queens must be properly managed and well mineralized for the production of good dairy feed.

Keys to Abundance

(*From page* 15)

field for some very important work by plant breeders and geneticists.

It might be objected that from the standpoint of human nutrition it would be useless to push the production of nonprotein vegetable substance to such extreme limits while the direct production of protein remains under an iron-bound restriction. But the 2,000-lb. limit on protein direct from the soil may easily be by-passed by calling in certain microorganisms that have ability to convert a superabundance of carbohydrates into first-class protein food. Thus, a perultimate crop of POJ 2878 will yield enough fermentable material to produce about 25,000 pounds of edible yeast (Torula utilis) containing about 12,500 pounds of true protein, which is enough to furnish a

standard protein ration (100 grams a day) to 149 persons for a year. Compare this with an average wheat crop (20 bushels), which will take care of the yearly protein needs of two persons. Should the breeders find a cane variety with 0.1% of nitrogen, one acre thereof could furnish about 420 yearly protein rations.

While we are waiting for the breeders to come up with crop plants with 0.1% of nitrogen or less and capable of approaching acre-yields of a third of a million pounds of dry substance that may be converted into protein for man and his animals, we will do very well to make full use of what is now "in the bag," as it were. We already have crop plants that contain from 3.200 down to 0.285% of nitrogen, and when selected according to their climatic requirements and grown on well-watered, perfertile soils they all may be expected to give their perultimate yields. And the perultimate yields of them are vastly greater than the average yields of these same crops obtained even by the world's best farmers who till their soil in ignorance of the law of yield. Take wheat, corn, and potatoes, which are the world's principal food crops. The agrobiologic potential of a good variety of wheat is 171 bushels, of corn 250, and of potatoes (tubers) 1,559 bushels. These potentials have been closely approached in well-controlled experiments and in the open fields where growing conditions have been exceptionally good (5). Compare these potentials with the respective averages of these crops in the United States: 20, 28, and 150 bushels. The conclusion is that the arable lands of the United States are being operated at one-tenth to one-eighth of their real capacities, or rather the capacities of the crop plants that grow on them. In some parts of the world (northwestern Europe) the coefficient of agrobiologic efficiency is a little more than one-fourth, but for the rest of the world it is no better than in the United States.

The world's food position would be greatly relieved if the world's soils were made no more than half perfertile, that is, capable of evoking half (50%) of the quantities of life inherent in the world's food plants. This would mean a general increase of about five times the current average rate of production; and even if the world's soils were no more than one-fifth perfertile, the present yield of food would at least be doubled. Deficiency of food in the world is not the fault of the food plants man now has at his disposal; "they have the goods" and will make delivery whenever their terms, which do not go beyond the cost of constituting a perfertile and well-watered soil, are met.

Conclusion

The agrobiologist can say, with confidence, that the race against world hunger has already been won in principle, so far as acquisition of the necessary basic knowledge is concerned. The life-potentials of the common crop plants have been evaluated, and they are enormous. The parameters of a perfertile soil have been determined, and the means for constituting such soils are not too formidable in view of the ends to be served. The effect law of the factors of plant growth and the inverse yield-nitrogen law supply the keys for unlocking the fabulous wealth of the kingdom of Flora that heretofore have remained invisible. To make this wealth available will require the intelligent investment of large resources and perhaps some rearrangement of the social-economic structure of agriculture. But the advantage of a comfortably fed world may well be weighed against the devastating evils that result from a mounting pressure of population against the means of subsistence.

The world desperately needs a better agriculture, which is now technologically within its reach. It will also need a statesmanship capable of supervising the transition of agriculture from its present empiric regime to a regime of agrobiologic science. In turn, the statesmen will need the orienting assist-

ance of agrobiology-conscious plant physiologists and agronomists, of whom there are as yet not very many.

References

1. Mitscherlich, E. A., Das Gesetz des Minimums und das Gesetz des Abnehmenden Bodenertrags. *Landwirthschaftliches Jahrbuch 38,* 595 (1909).
2. Willcox, O. W. The ultimate limit to sugar production. *Facts About Sugar,* February 28, 1928. So far as the writer knows this is the first mention of the inverse yield-nitrogen law as a general principle of plant life.
3. For a recent thoroughgoing experimental verification of the Mitscherlich yield equation see Mitscherlich, E. A.: Das Ergebnis von über 27,000 Feld-Dungungsversuchen. *Zeitschrift Pflanzenernährung Dungung Bodenkunde 38,* 22 (1947); S. Gericke. *Ibid.* Untersuchungen über das Ertragsgesetz. I, *Ibid.,* 54; II, 215; III, *39,* 245 (1947). These reports give the results of more than 27,000 standard field tests on many types of soils with nitrogen, phosphate, and potash and rye, wheat, oats, barley, potato, fodder beets, sugar beets, rape, meadow hay, red clover, corn. As one example of the agreement between fact and theory the composite result of 2,151 trials with potash and the four food grains may be quoted:

K_2O (x), dz/ha.....	0.0	0.6	0.8	1.2
Yield (y), dz/ha, found.	24.5	26.2	26.7	27.6
Yield, dz/ha, caled....	24.5	26.3	26.7	27.4

4. Cf. Willcox, O. W. Why some crop plants yield more than others, *Science, 108,* 38 (1948).
5. See the writer's books: Reshaping Agriculture (1934); A B C of Agrobiology (1937).
6. The Law of Diminishing Returns, by W. J. Spillman (1924).

Corn Reflects Potash Supply

(*From page* 17)

ear samples were gathered from six hills on the heavily potash-treated area and a similar number from the adjacent no-potash area. The difference was as illustrated by Figures 1 and 2.

After allowing the corn to dry for several months at room temperature, the calculated yields showed a production of 125 bushels per acre for the corn grown on the heavily potash-fertilized soil and 72 bushels per acre for the corn grown adjacent but not on the heavily potash-treated area. These yields show that potassium can be used in amounts heavy enough to satisfy what would appear to be the maximum needs of the growing plant.

Its use in mixed goods in smaller amounts suggests that while this is of value to the crop in its early stages of growth, it has seemingly not been sufficient to give increases over superphosphate used alone. For this reason recommendations for potash use have been on the basis of a supplementary or starter plant food in place of the equivalent of plant removal as is often true in the case of limestone and phosphate. These results show the possibility of increases in yield and quality from the use of potassium applied in sufficient dosage to supply the undetermined plant needs.

TABLE I.

O.M. %	Lbs. per acre				pH	M.E. Total H/100 gms.	Notes
	P_2O_5	K	Mg	Ca			
3.1	42	52	190	3,720	6.3	3.0	K–deficient
2.5	42	154	180	3,720	5.8	3.5	K–solution

Covered Wagons

(*From page* 5)

world relations were spotty and sporadic way back then, although thousands of the denizens of the Orient and all parts of Europe joined our own reckless wealth seekers in blissful ignorance of two World Wars and a United Nations to come.

Indeed, our international indifference a century ago was right in tune with our rugged individualism. Each man who went westward was living for and to himself. He was out to "get his own" and to protect what he got himself. He cared little for the hardships of others or the fate of the Nation as a whole, with a few exceptions.

THAT much of this outlook is changed today we can plainly see and be glad about. For above all things that make for safe, sound, and reliable investment, we must have cooperative enterprise and progress and a helpful relationship between all forms of government and business as well as acceptance of international responsibility.

Modern security of investment based on progress is seen in the building of highways and electric power generators. The highway deal is very properly noted here because of the terrific toll in life and savings which the covered wagon folks suffered by reason of horrid roads or none at all.

We're doing pretty well on our "main-traveled roads." The public Roads Administration in cooperation with the States has built and maintains 231,900 miles of primary and 377,600 miles of secondary highways. Moreover, there are one and a half million miles of improved highways for our eager tires to kiss in 1949. If my poor footsore Illinois uncle were living and had enough jack to buy himself a second-hand jalopy, he could do the vast road to the Eldorado in just a few days, and then have lots of time left to sponge on our native California relations.

In the Electrical World for January 1949 I note with pride that the country's public and private electric utilities possess an installed kilowatt capacity of about 55 million—about 11 million kilowatts by local and Federal projects and 44 million through private outfits. And even with that impressive outpouring of power, we face a bad stringency. Scanning the Government works now being finished to augment this flow of energy unheard of in 1849, there are names of places which meant awe or terror to the overland travelers. Among them are dams to be erected at Ft. Randall and Garrison on the old Missouri, Boysen on the Big Horn, Heart Mountain on the Shoshone, Hungry Horse in Montana, Anderson Ranch in Idaho, and McNary on the Washington-Oregon boundary. These are much safer investments, I dare say, than the ones based on inflated prices and the gambling in "future" which our kinsfolk thought were wonderful risks one hundred years ago.

ANOTHER piece of big business financed by Government revenues is the Post Office Department. In 1849 Government postage stamps were two years old. It was not until 1862 that regular railway mail service started. The "rural free delivery" came to pass in 1896. The first postal savings were laid away in 1911. The parcel post system opened in 1913, and air mail earned its wings in 1918. And so today we have 490,000 workers in the country's busy mail service, serving 42,000 post offices, and handling many times

the annual "takings" of the best Gold Rush mines—fully $17 billions. Here we see a steady growth to meet popular necessity. This is just one of many things which modern people "demand" of their governments—local, state, and federal. Funds put into programs of such permanent kind may not draw as big interest as the bankers charged in Sacramento a century ago, but there won't be any absconding or defaulting.

At least four bureaus in the Interior Department and three more in the Agriculture Department tackle problems and policies and do investigating and planning about the very things which most perplexed and threatened the farmers and miners of 1849. Land patents, topographical and official maps, surveys of resources in forest and mine, and administering leasing laws therein are the jobs of the Bureau of Land Management. Irrigation, flood control, and hydroelectric power in the arid areas west of the 97th meridian are in the realm of Reclamation Bureau. Conservation of mineral resources, data on production, and aid in mine safety campaigns belong to Bureau of Mines. Education, training, and welfare of 400,000 native Americans and guidance in operating 56 million acres of their reservation lands are up to the Bureau of Indian Affairs.

ORGANIZED soil conservation districts cover over 700 million acres of land, with better farming adjustments made already on 25 million acres. Old trails of the pioneers are now improved highways stretching through 152 national forests of about 300 million acres, administered by U. S. Forest Service, fire-protected and patrolled to a growing extent. County-by-county organizations of farmers to stop erosion, grow better pastures and enrich the land are run by the Agricultural Conservation people. It's not quite too late to halt the waste which past citizens of our rich, new country so easily squandered and forgot. Lots of that waste followed right in the wake of the covered wagons, too.

As we knew a long time ago, and don't need any more lectures on, all this (and much more) in public works for private welfare costs money. So in this enlightened day and age the U. S. Government borrows to reduce the debts and pay for the current running expenses. It likes to borrow (sell U. S. Series E savings bonds) from folks like you and me, who just have a slight speaking acquaintance with a banker. The financial wizards tell me that widespread sales to everyday investors keep them from taking risks again with the old sock and the clock-shelf hideaway, and likewise helps to hold back speculative inflation.

I UNDERSTAND that the covered wagon will be featured widely and effectively in the launching of the next sales campaign in behalf of these Series E savings bonds. It is slated to start officially May 16 and will run on until July 1. They hope to sell a trifle more than one billion in these securities, mostly by payroll savings and bond-a-month plans. To farm folks who already hold six billions in Government savings bonds against about five billions in real estate mortgages, the current outlook is a little "mixed" on the income side, but pretty safe and sure on the matter of choosing reliable investments.

Unlike their roving ancestors of the western hegira, our neighbors on the farm do not intend to toss their land, livestock, and lives in the dice game. Their lives are too precious and their land and livestock values fluctuate too fast sometimes to rely upon as ultimate, reliable anchors to the windward. But "how much" they can afford to salt down in bonds is going to depend on how farm prices act this summer and fall. You can't possibly "stampede" corn-planting and weed-killing farmers into any quickie investment buying program, no matter how sound. I pre-

dict they'll take their own sweet time after listening and asking questions when the volunteer salesmen come around. Then maybe after talking it all over with the Missus some night after chore time, Mr. Average Farmer is going to step into the local bank and peel off some of his harvest roll to put right into that safe place where it will always be readily available—come hell or high water.

I guess that way from long, chummy relationships with outdoor producers, who do much and talk little—but think darn hard. They want to know first-off what the bonds mean and the interest earned and how cashable they are in an emergency. Nine times out of ten, farmers know how safe Series E savings bonds are, because they know and respect the good old "Guvmunt" no matter how much they lambast and criticize. That again links these modern farmers with the old Forty-Niners, whose speech was rude and forceful, but who really wanted law and order back again. Finally, they want to know where they can get savings bonds and how much they'll cost, money on the barrelhead. All the rest you can just safely leave with the w. k. Weather Man and the performance of the price lists. I am betting, however, that even if a bad season strikes us and some farm prices waver downward you'll not have much trouble convincing farmers where their best investments lie.

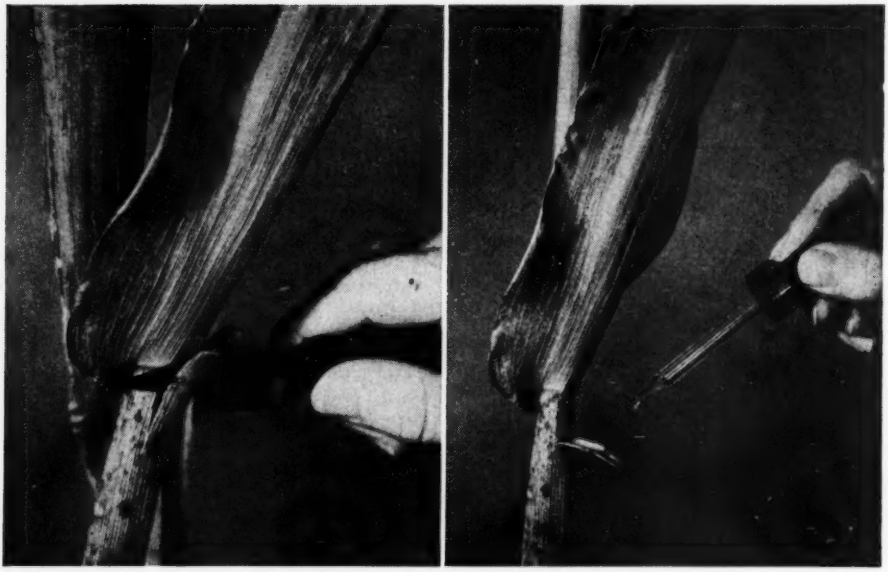
TAKE Tipton County, Indiana. That's as close to the heartbeat of the bread basket as most any place where farmers prosper. Recently I spied a little piece that said 14,000 inhabitants of Tipton county had laid away almost ten million "smackers" in U. S. savings bonds. In good times they keep what they earn, too—witness that a local banker claims there are about nine out of ten of those crackly documents left in the deposit boxes. So-called redemptions are lower in rural centers.

After all, you can brag a lot about organized programs of this and that to "save the farmers"—public and private—and it all simmers down to the same old fact; namely, that farming is hazardous and speculative owing to being a constant partner with fickle Dame Nature. There is no one cure-all for that situation—not even joining an organization or taking out crop insurance.

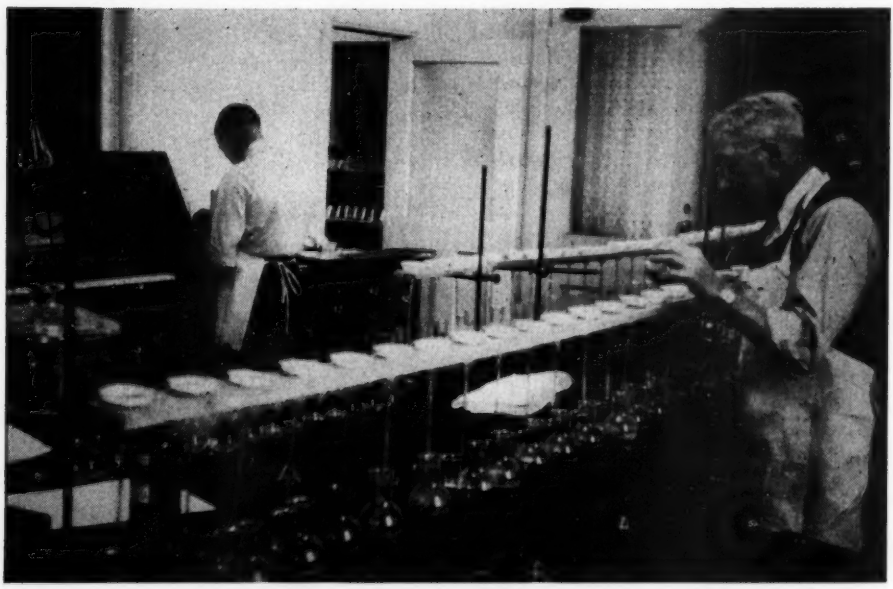
IN good times the farmer lays away some financial fat on his ribs. He and his family and business operations require such precautions against the evil day when plagues and drought and flood (or low prices) kick him in the pants. That in doing his investing the farmer will choose a real gilt-edge, fool-proof, sure-fire kind of paper has been shown in every U. S. savings bond issue since before the war.

And one more point you might forget otherwise. The average age at death in this United States today is a little over 67 years. The Public Health Service told me the other day that only as far back as 1900 the average age was well under 40 years. I shudder to think what the actual average person's age was when they all piled into the covered wagons. Anyhow, what I drive at is that a man in his prime today has a longer life to plan for, and that means increasing his estimated lifetime savings reserve. I never saw a guy yet, farmer or otherwise, who wanted to spend his grandpa days in some chimney corner as an object of charity. At this point you can page the grasshopper and the honeybee to point a moral and close a tale.

So we no longer yoke the oxen to a mammoth wagon to carry us on to the Land of Opportunity. Our new Frontiers are crowding around us closer and more complex than ever. We must meet the situation right here and now, with one eye on world peace and the other on personal security. If we're thrifty and provident we'll reach them both—but not with covered wagons!



Nitrate tests can be made at the base of the leaf midrib without destroying the entire plant. This is an important consideration in making numerous tests on small experimental plots. The height of the plant at which nitrates are present as well as the intensity of the blue color gives an indication of the nitrate status of the plant.



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Recently a number of letters were sent out to a selected list of men as to how to hold a wife. The first answer received was from a western penitentiary. It stated briefly: "I found the best way was around the neck, but it shouldn't be overdone. Please note change of address."

* * *

"As I understand the case," said his honor, "you and your husband had a drunken altercation and you were kicked in the ensuing rumpus."

"No, sah, Jedge," replied Mandy. "Ah was kicked in de stummick."

* * *

A roaring twister last Wednesday carried off Jem Benson's house and furniture, and all three of his children are missing. Neighbors donated a new bed to give Jem and his wife a fresh start.

* * *

Uncle Jake, the town character, was 80 years old.

"Don't you hate to grow old?" he was asked.

"Heck, no," says he. "If I wasn't old I'd be dead."

* * *

When the white man discovered this country, the Indians were running it. There were no taxes, there was no debt. The women did all the work. And the white man thought he could improve on a system like that!

Sally: "Does she stutter?"

Jane: "Does she? Why, once she started to tell a man about her past, and before she had finished he was part of it."

* * *

Seven-year-old Susie received a box of scented soap for her birthday. A neighbor, admiring it, told Susie that she always placed a cake of perfumed soap among her underthings to keep her clothes smelling nice.

Later, Susie complained to her mother: "I don't understand that Mrs. Ross. I keep putting a cake of soap in my underwear but when I walk around it always drops out."

* * *

Pretty Babe Buxom, who has more boy friends than any girl in town, was voted Miss Community Chest for this year.

* * *

Doc — "Your mother-in-law's condition necessitates a warmer climate."

Newlywed (After a short reflection) —"You do it Doc. I haven't the heart."

* * *

A mountaineer from North Carolina took a trip to New York—his first visit to a large city. On his return, a friend asked how he liked New York.

"Well," said the traveler, "to tell the truth, I never did get to see the town—there was so much going on around the depot!"

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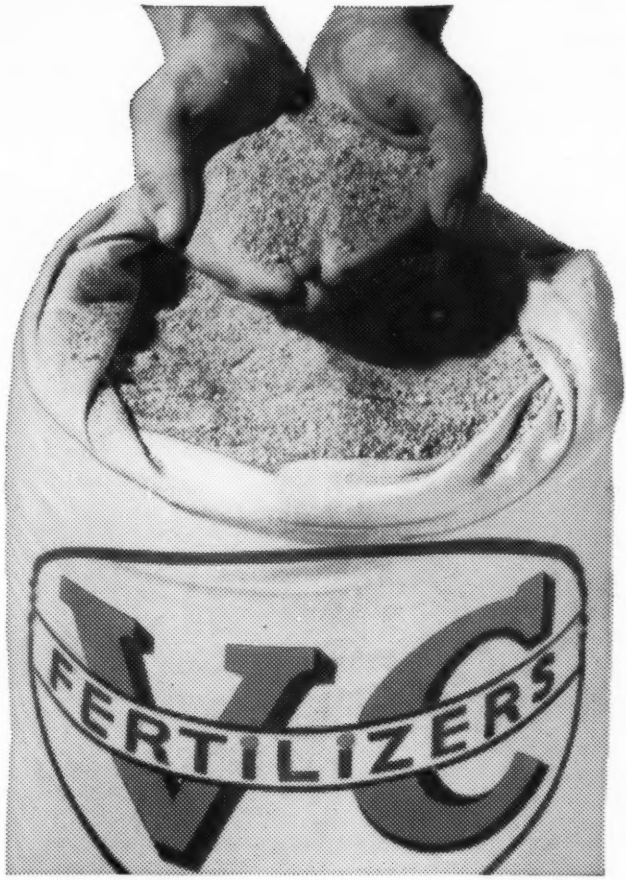

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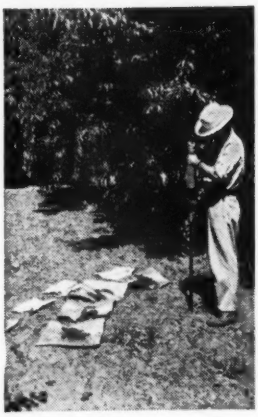

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